



**ZOE STELIANA
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**DEFINING THE ECONOMIC VALUE OF THE
ECOSYSTEMS LOSS IN RIA DE AVEIRO**



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Dissertation presented to the University of Aveiro as requirement for obtaining the Master Degree in Environmental Engineering in the scope of the Environmental Engineering Master Programme, with scientific supervision of Prof. Dr. Maria de Fátima Lopes Alves, Invited Auxiliary Professor of the Environment and Planning Department of the University of Aveiro.

Ad astra per ardua.

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palavras-chave

valorização dos ecossistemas, lagoas costeiras, governança

resumo

As zonas costeiras abrangem cerca de 84% dos países do mundo. São áreas de elevada importância, pelos ecossistemas presentes, que de diversas formas potenciam actividades como o lazer, o recreio para além das actividades comerciais. Constituem ainda locais privilegiados para a habitação permanente e sazonal para a população, em geral. O interesse em produzir informação sobre o estado dos ecossistemas costeiros, em termos ecológicos, económicos e sociais, tem vindo a aumentar na última década. Actualmente, assiste-se a diversas tentativas de quantificar o valor económico dos ecossistemas, no sentido de que este poderá constituir um importante contributo ao planeamento, ordenamento e gestão do território, em particular, aos territórios costeiros como as zonas húmidas.

A presente investigação teve como objectivo principal, fazer uma primeira abordagem metodológica, de avaliação do valor económico dos ecossistemas presentes na Ria de Aveiro. Complementarmente, efectuou-se uma análise dos principais projectos de gestão integrada das zonas costeiras e de planos de acção que foram, ou estão a ser, implementadas nesta área.

A avaliação económica efectuada foi baseada, em primeiro lugar, numa pesquisa bibliográfica existente nas principais revistas científicas, nesta matéria, e ainda nos documentos técnicos mais relevantes produzidos por instituições e organizações que têm vindo a divulgar diversos estudos, nos últimos anos. Este processo exploratório permitiu identificar os métodos utilizados e os valores associados a determinados ecossistemas. Seguidamente, e após a definição da área de estudo foram analisadas as mudanças e transferências de uso do solo ocorridos entre 1990 e 2006, na área envolvente da Ria de Aveiro, tendo sido aplicada uma valoração económica a cada um dos ecossistemas, presentes na área de estudo.

A Ria de Aveiro desempenha um importante papel na qualidade do ambiente e na economia local. Contudo, nos últimos vinte anos a intensa pressão humana e turística, sobre este ecossistema, deixou uma forte marca no território, marca esta bem patente nas alterações de usos do solo observadas. Contudo, nos últimos anos ocorreram intervenções destinadas a promover a conservação, reabilitação e recuperação das áreas mais sensíveis quer do ponto de vista social, económica e ambiental. Deste modo, constituiu objectivo final, deste trabalho, verificar as perdas reais dos ecossistemas da Ria de Aveiro e compreender a sua tradução, em termos económicos..

keywords

ecosystem valuation, coastal lagoon, governance.

abstract

Coastal zones, bathing 84% of the countries of the world, are important ecosystems that facilitate leisure, recreational and tourism activities, host strategic ports of commerce and provide opportunities for permanent living for the population. The interest in generating information about the coastal ecosystems' status in ecological, economic and social terms, has only risen in the last decade and at the moment, attempts to quantify their economic valuation brings an important contribution to management plans, as well as to wetland conservation approaches.

The main objective of the present thesis is to assess the economic value of the ecosystems found in the Ria de Aveiro Lagoon, as well as to compare some of the main research and action plans that were implemented in the area in the past ten years.

The economic valuation was based, firstly, on a research on the existing bibliography, in order to identify the methods used and the associated values for certain ecosystems. Second, after defining the study area and highlighting the main approaches in term of management plans and programmes, were analyzed the changes and transfers of land use that took place from 1990 to 2006, having applied the economic values.

The Ria de Aveiro brings an important contribution to the local economy and to the environment and in the past twenty years the human pressure has left a strong mark upon it. However, the latest interventions aimed at promoting the preservation, rehabilitation and recovery of the most sensitive areas, socially and economically, as well as environmentally. The purpose of this work is to ascertain the real losses of natural ecosystems in the Ria de Aveiro and translating them into economic terms.

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List of Abbreviations

AC - Avoided Cost
AL - Arable Land
APA - Administration of the Port of Aveiro
ARH Centro, I.P. - Administration of the Hydrographic Region of the Center
ASPA - Avifauna Special Protection Area
CCDRC - Commission for the Coordination and Regional Development of the Center
CEC - Commission of European Communities
CLC - CORINE Land Cover
DRAOT Centro - Regional Directorate of Environment and Territorial Planning of the Center
DRIA - Department of the Ria de Aveiro
ESF - Ecosystem Services Framework
F - Forests
FI - Factor Income
GIS - Geographic Information System
HAA - Heterogeneous Agricultural Areas
HP - Hedonic Pricing
ICTU - Industry, Commerce and Transport Units
ICZM - Integrated Coastal Zone Management
IUCN - International Union for Conservation of Nature
IW - Inland Waters
IWL - Inland Wetlands
MAOTDR - Ministry of Environment, Territorial Planning and Regional Development
MDCS - Mine, Dump and Construction Sites
MEA - Millennium Ecosystem Assessment
MMU - Minimum Mapping Unit
MW - Marine Waters
MWL - Maritime Wetlands
NSICZM - National Strategy for Integrated Coastal Zone Management
NUTS - Nomenclature of Territorial Units for Statistics
OSLNV - Open Spaces with Little or No Vegetation
P - Pastures
PBRH - Hydrographic Region Management Plans
PES - Payments for Environmental Services
PMD - Public Maritime Domain
RC - Replacement Cost

SHVA - Scrub and/or Herbaceous Vegetation Associations

TC - Travel Cost

TEEB - The Economics of Ecosystems and Biodiversity

UF - Urban Fabric

UNEP - United Nations Environment Programme

WFD - Water Framework Directive

WL - Water Law

WTA - Willingness to Accept

WTP - Willingness to Pay

WWF - World Wildlife Fund

Chapter I

Introduction

1.1. Theme framework

Ecosystems support human life and activities, providing goods and services for the sustainable well-being, as well as future economic and social development. However, there are precisely the human activities that destroy biodiversity and alter the capacity of healthy ecosystems to deliver each other's range of good and services. The loss of services from natural ecosystems require costly alternatives, therefore investing in natural capital presents interest in welfare and long-term survival.

Planet Earth is a coastal planet, comprising 361.13 million km² of water (71% of total planet surface) and 148.94 million km² of land area (29% of total planet surface), whose interaction intensively and extensively lies along the world's total 1,634,701 km of coastline. About 84% of the countries of the world have a coastline either with the open oceans, inland seas or both, resulting in a variety of geomorphological features, weather regimes and biomes. The coasts include soft-shores, rocky shores and cliffs, hilly or flat coastal plains, narrow or wide coastal shelves and a wide variety of wetlands (estuaries, saltmarshes, and deltas). Nevertheless, human beings have not been insensitive to the wide array of opportunities provided by the coasts and have been attracted to them, making the coasts the most favored locations to either live permanently, for leisure, recreational activities, or tourism. The coasts also host the world's primary ports of commerce. However, it was only within the last decade that global information of the coasts have been generated via remote sensing technologies and satellite imagery,

providing the opportunity to integrate and summarize the available information to develop a comprehensive picture of the status of coastal ecosystems and to evaluate their relative importance in terms of their ecological, economic and social attributes.

Economic values can be quantified through a process that is called economic valuation of ecosystems. For the wetland goods and services that are traded in the market place, whose prices are not distorted, market prices can be used as indicators for economic values. Often, however, most goods and services do not have a market price and their economic values are determined through shadow pricing techniques. Economic theory distinguishes several shadow valuation methods, like: Contingent Valuation, which directly obtains consumers' willingness to pay for a change in the level of an environmental good (based on a hypothetical market), or the Travel Cost method, that relies on individual valuations of environmental goods that are revealed in the travel costs made by consumers to obtain the environmental good, such as distance costs per kilometer travelled, time costs of the individual, and the entrance fee of the particular environmental good.

Economic valuation of wetlands has two benefits. Firstly, economic valuation is an important factor in highlighting the relative importance of different economic activities that depend on wetland functions, bringing an important contribution to management plans of wetlands. Secondly, economic valuation may be useful in countering arguments on wetland conservation. Putting a monetary value on activities can highlight the significance of wetlands for people and thus provide strong arguments for the conservation of wetland lands and water as opposed to reclamation or diversion. In both cases, monetary valuation is an important complementary assessment to other, qualitative assessments on wetland functions that cannot be monetized.

Key ecological goods and services were always regarded as being essential to human welfare, together with unique environments and natural habitats, and irreplaceable ecosystem attributes. However, their true value was always uncertain, particularly the value that future generations may place on them if they become increasingly scarce. This concern is reflected in various definitions of sustainable development. For example, in

1991, the World Wide Fund for Nature, the International Union for Conservation of Nature (IUCN), and UNEP interpreted the concept of sustainable development as “improving the quality of human life within the carrying capacity of supporting ecosystems” (WWF; IUCN, 1991; UNEP, 2011).

It is stated that coastal and estuarine environments are privileged localizations for biodiversity evolution, being extremely sensitive to changes in the boundary conditions, particularly in water properties. Further analysis in order to foresee the behavior of water flows, temperature distribution and salinity is therefore needed.

Ria de Aveiro is such a system, a shallow water lagoon with complex geometry, connected with the Atlantic Ocean through a single artificial canal. Water exchange with the ocean is realized through tidal input/output across this narrow entrance. The input of fresh water occurs through several small rivers distributed by different canals of the lagoon, most important of which is Vouga (Nolasco *et al.*, 1999).

1.2. Objectives

The work develops as a main objective the economic valuation of the ecosystems found in the area of Ria de Aveiro. Beside the environmental and ecological points of view, the paper attempts to assess the Governance approaches for an integrated coastal zone management and the development plans that covered it during the past decade.

The specific objectives aimed at are:

- Identifying the main ecosystems found in the study area;
- Understanding the concepts of ecosystem services and functions, and ecosystem payments;
- Analyzing the land evolution in the study area, and assessing it from an economical point of view;
- Understanding the importance of the Geographic Information Systems (GIS) databases in identifying the changes in land use;

- Presenting a methodological approach in assessing the economic value of ecosystems, applied to the Ria de Aveiro, a biodiversity enriched area, whose potential is endangered by the development of human activities, mostly aggressive to the ecosystems.

1.3. Methodology

In order to achieve the proposed objectives, was analyzed the existing literature regarding the topic of economic valuation of natural ecosystems. This way, it was possible to identify various methods used in the valuation of ecosystems and to find a set of economic values associated with each ecosystem, based on the services and functions they provide.

Later on, proceeding to the aid of GIS, was established the study area and an analysis of land use for three different years (1990 | 2000 | 2006) was performed, based on the CORINE Land Cover (CLC) mapping, implemented with the aim of developing an information system on the environment at a European level (Caetano *et al.*, 2005).

Having made the analysis of the studied periods, were analyzed the changes and transfers of land use that occurred in the study area, in order to obtain an evolving perspective of the land use and consequent changes in the ecosystems present in the study area.

After identifying these changes, and once having established a correspondence between the types of land use and ecosystems identified in the literature, the referenced economic values were applied and calculated for different periods.

With this methodology it was possible to highlight those areas where there were more significant environmental losses and confront them with the investments in restoration, enhancement and protection provided to the study area. The following figure presents synthetically the present methodology.

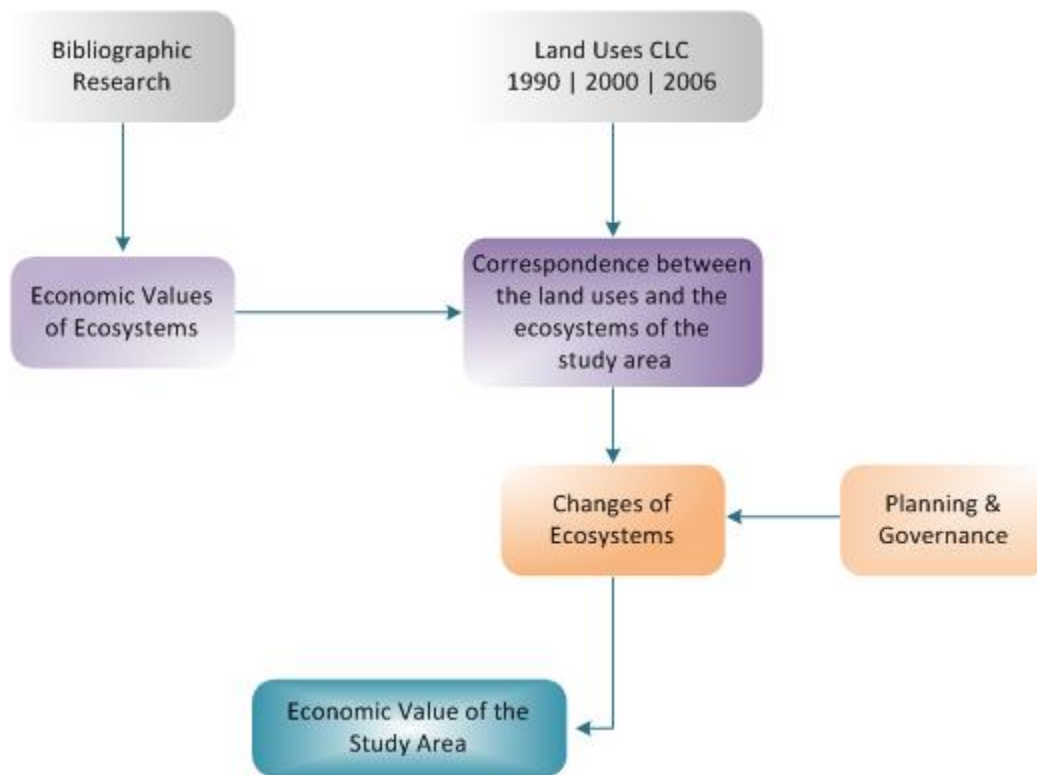


Figure 1.1. Methodological structure of the research

1.4. Structure of the document

The present thesis is organized in four chapters.

The first chapter presents a framework which shows the relevance of the topic, introducing as well the objectives, the methodology adopted and the organization of the work.

The second chapter presents various concepts and definitions in the area of ecosystem services and values, as well as their characterization and classification, focuses on the littoral ecosystems and highlights several issues about the ecosystem service framework and payments.

The third chapter realizes a biophysical, socio-economic, legislative and strategic characterization of the Aveiro lagoon, analyses the spatial plans and programmes applied in the study area so far and presents the economic valuation of the existing ecosystems.

The final chapter highlights the main conclusions and considerations, presenting a couple of recommendations and guidelines for future developments.

Chapter II

Concepts and definitions

in the area of ecosystem services and values

2.1. Introduction

Services of ecological systems and their correspondent natural capital stocks are critical to the functioning of the earth's life support system. Their contribution is brought significantly to human welfare, both directly and indirectly, representing a significant portion of the total economic value of the planet. However, these services are given too little weight in policy decisions, as a result of their incomparability with economic services and manufactured capital, despite the fact that this might actually compromise the sustainability of humans in the biosphere. The economies of the earth would stop operating without the services of ecological life support systems, so in one sense their total value to the economy is great. Many studies in the past few decades aimed at estimating the value of a wide variety of ecosystem services. According to a set of authors, this kind of exercise was essential in:

- Making the range of potential values of the services of ecosystems more apparent;
- Establishing at least a first approximation of the relative magnitude of global ecosystem services;
- Setting up a framework for their further analysis;
- Pointing out those areas most in need of additional research; and

- Stimulating additional research and debate (Costanza, 1997).

The concept of ecosystem services is still new to many biologists and environmental scientists. This poses two major difficulties. First, it requires scientists to change their frame of mind to an anthropocentric perspective. Second, it requires scientists to familiarize themselves with tools for the valuation of ecosystem services, including economic tools. Since 1983, a great number of papers have been addressing the concepts of '*ecosystem services*' or '*ecological services*' and is still rising exponentially. Concerning the consequences of ecosystem change for human well-being, The Millennium Ecosystem Assessment (MEA)¹, an international assessment designed to meet the needs of decision makers for scientific information, was also among the first to offer a classification system that is nowadays widely used. However, the MEA classification of: *supporting*, *regulating*, *provisioning* and *cultural services*, is not meant to fit all purposes, thus making it necessary to agree upon a functional definition, that may allow for meaningful comparisons across different projects, policy contexts, time and space (Boyd, 2007; Barbier, 2007). The MEA definition of ecosystem services state them as benefits people obtain from ecosystems, including things outside of ecological systems such as imputed cultural meanings, recreation and spiritual fulfillment, whereas Boyd and Banzhaf (2007) highlight the role of science, in delivering the information to society.

The classification system should therefore be informed by a clear and robust definition, the characteristics of the ecosystem or ecosystem services under investigation and the decision context or motivation for which ecosystem services are being considered. Once defined, it is very easy to consider ecosystems' characteristics, as well as the ones of the systems' from which they derive, understanding their link with human welfare. The final approach would be acknowledging the decision context and motivations for mobilizing ecosystem services research.

¹ The Millennium Ecosystem Assessment was launched by UN Secretary-General Kofi Annan, and was designed to meet some of the assessment needs of the Convention on Biological Diversity, Convention to Combat Desertification, and the Ramsar Convention on Wetlands. The MEA is a multi-scale assessment, consisting of interconnected assessments at the global, sub-global and local levels.

Moreover, despite the fact that the term and concept of ecosystem services has received such a great interest in the past decades, there has not yet been developed anything like an operational decision-support system. The Ecosystem Services Framework (ESF) outlines the long-term role that healthy ecosystems play in the sustainable provision of human well-being, economic development and poverty alleviation all around the world. It takes an efficient and effective management of ecosystems in order to provide vital ecosystem services, such as climate stabilization, drinking water supply, flood alleviation, crop pollination, recreation opportunities and amenity, as well as cultural assets (Holdren and Ehrlich 1974; Westman 1977; Daily 1997; Balmford *et al.* 2002; Turner *et al.* 2003; MEA, 2005).

People depend on nature, and people too often damage nature, thereby endangering their own health and well-being. The contribution of the MEA was its championing of a new scientific focus, a focus on understanding how nature produces a wide array of ecosystem services, quantifying the rate and value of the delivery of these services, and modeling the connections between ecosystem services, human welfare, and economic systems. MEA's contribution might have presented huge gaps in the science of ecosystem services; however both conservation and economic development communities embrace ecosystem services, without explicitly labeling them as such. This melding of conservation and development comes from two distinct agendas: conservationists who seek to increase public support for biodiversity protection by integrating economic development, and development agencies that seek to also provide for the stewardship of nature under the mantra of sustainable development (Tallis *et al.*, 2008). All these projects have variously been categorized as integrated conservation-development projects, community-based natural resource management, and, most recently, pro-poor conservation.

2.2. What they are?

An ecosystem is a complex of dynamic sequence of plants, animals, micro-organisms and the natural environment, that co-exist as a whole unit, in interdependence. The planet's ecosystems provide humanity with a wide range of benefits, namely 'ecosystems goods and services'. Ecosystem goods consist of food, water, fuels and timber, while services

include water supply and air purification, natural recycling of waste, soil formation, pollination, and a set of regulatory mechanisms that nature uses to control climatic conditions and populations of animals, insects and other organisms. Because many of the goods and services have always been freely available, their true long-term value was never included in society's economic estimates.

The main categories of ecosystems and the services they each provide, as stated in the MEA (2005), are:

- Marine - fish and other seafood (commercial and subsistence fisheries), ecotourism, recreation, medicinal products, climate regulation, transportation, freshwater cycling;
- Coastal - tourism, recreation, cultural value, fisheries (commercial and subsistence), aquaculture, transportation, nutrient cycling, storm/flood protection, climate regulation, disease regulation, waste processing, erosion control, hydropower, freshwater storage;
- Inland Water - crops, fisheries, freshwater, storage of greenhouse gases, groundwater recharge and discharge, water for agriculture and industry, detoxification of water, flood control, recreation, tourism, cultural value, sediment retention, hydropower, nutrient cycling;
- Forest and Woodlands - pollination, medicines, food, erosion control, water regulation, timber, biofuel, food, climate regulation, disease regulation, tourism, recreation, cultural value;
- Dry lands - soil conservation of moisture, nutrient cycling, food, fiber, biochemical, biofuel, pollination, freshwater, water regulation, climate regulation, cultural value, tourism;
- Island - fisheries, freshwater, tourism, recreation, timber, fuel, cultural value, flood/storm protection;
- Mountain - freshwater, food, medicinal plants, natural hazard regulation, climate regulation, soil fertility, water regulation, recreation, tourism, cultural value, fuel, rangeland for animals;

- Polar - climate regulation, freshwater, fisheries, game animals, fuel, fiber, cultural value, tourism, recreation;
- Cultivated - food, fiber, fuel, pollination, nutrient cycling, soil formation, pest regulation, freshwater;
- Urban - ecosystem services generally consumed rather than produced; services supplied by green spaces and parks include: air quality, microclimate regulation, noise reduction, water regulation (surface water drainage), pollination, genetic libraries, pest regulation, waste processing and recycling, cultural value, recreation, tourism (urban gardens and parks).

The concept of ecosystem services encompasses the delivery, provision, production, protection or maintenance of a set of goods and services that people perceive to be important (Chee, 2004). Humanity's reliance upon nature for welfare and survival is complete. Its services have been managed directly in order to increase productivity, recognizing in this way their importance. It was in 1977, that Westman (1977) referred to the benefits that ecosystems provide as 'nature's services', and later in 1981, that Ehrlich and Ehrlich (1981) first introduced the term of 'ecosystem services'. However, in spite of the concept's history, the literature has not agreed yet upon an exact definition (Boyd, 2007; Barbier, 2007). The most common cited definitions are:

- The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life (Daily, 1997);
- The benefits human populations derive, directly or indirectly, from ecosystem functions (Costanza *et al.*, 1997);
- The benefits people obtain from ecosystems (MEA, 2005).

Though these definitions might agree on the same idea of ecosystem services, there are still some important highlighted differences. The concept is being referred to as: '*conditions and processes*', '*goods and services derived from the functions*', as well as '*benefits*'. Usually the language surrounding this issue takes many forms.

Boyd and Banzhaf (2007) were the ones who introduced an alternative definition to the ones already presented. In their assumption, final ecosystem services are ecological components directly consumed or enjoyed to produce human well-being. They also state that final ecosystem services are directly enjoyed or used, that they are components, and that they are a quantity to be paired with a price (value). Making a distinction between end-products and intermediate products is essential in welfare accounting, in order to avoid double counting. It is notable, as well, that final ecosystem services are not necessarily the final product consumed, though they might be end-products of nature. Ecosystem services are '*components*' (Boyd and Banzhaf, 2007), representing things or characteristics, not functions and processes. Ecosystem components include resources such as surface water, oceans, vegetation types, and species populations. Ecosystem processes and functions are the biological, chemical, and physical interactions between ecosystem components. Functions and processes are not end-products; they are intermediate to the production of final ecosystem services. Also, in a conventional economic account, another distinction is being made between the quantity of ecosystem services and their value. There are few definitions that actually focus on the ecological input as a quantity unit, while maintaining an appropriate price unit.

A recent definition states that ecosystem services are the aspects of ecosystems utilized (actively and passively) to produce human well-being (Fisher *et al.*, 2009). The key point of this approach is precisely the fact that functions and processes become services if there are human beneficiaries.

In a work on the diversity of the ecosystem services concept, Lamarque (2011) introduces a series of terms and concepts that have been developed in other contexts and disciplines. Ecosystem services are broadly defined in references as the benefits people obtain from ecosystems. In addition, the term of ecosystem goods is sometimes used for those services that have a direct market value such as food but both tangible goods and immaterial services provided by ecosystems are now generally labeled as ecosystem services.

Ecological services have been used by some authors as a synonym to ecosystem services but the term sometimes refers to services provided by a particular species or group of species rather than processes occurring at the ecosystem level.

Landscape services and the terms land, land-use and landscape functions are widely used referring to services supplied by regions, landscapes or land-use systems with the technical and socio-economic characteristics of the land. However, landscape services are considered to differ from ecosystem services as they stress explicitly on the underlying role of spatial patterns, landscape elements and horizontal landscape processes.

Environmental services are often used as a synonym of ecosystem services in Payments for Environmental Services schemes (PES), where stewards are paid by third party beneficiaries for an activity aimed at intentionally transforming or maintaining some useful characteristics of an ecosystem (or landscape) The term is also used for labeling human-made services that substitute ecosystem services totally or partially. This fits with the use of the term to label waste and water management services. The term sometimes also refers to the services provided by the abiotic environment such as the wind or water regimes used for generating electricity.

The terminologies differ in terms of key components and processes necessary to deliver an ecosystem service (services providers, including '*service-providing units*' and '*ecosystem services providers*') and human interventions in their delivery.

2.2.1. Which are their characteristics?

In order to better manage and evaluate ecosystem services, as well as to understand their ecology-society link, it is important to acknowledge their key characteristics that might be considered for decision-making and general motivations behind the use of this concept (Fisher *et al.*, 2008):

- **Public-private good aspect;**

Goods and services can be characterized along from rival to non-rival and from excludable to non-excludable, following an economic approach. Ecosystem services

provide benefits that are both rival and excludable. They can be traded in conventional markets, typically considered as private or market goods, while others are known as toll or club goods. These are neither non-rival, nor excludable. Then again, there are goods that are rival, but non-excludable. These are called open access or common pool sources. One last category would be represented by pure-public goods, which are neither rival, nor excludable.

However, there is a great amount of goods and services in between categories, the use of which is more difficult to exclude, making the classification purely stylized. Stability, resilience and resistance roles of biodiversity for ecosystem functioning, along with service provision are other characteristics that relay non-excludability and non-rivalry to society. Moreover, the understanding of how ecosystem services and their benefits fit into the public-private goods aspect stands in the social systems that interface with them. Complex and dynamic factors like governance systems, market, and informal land use interact in different categories of goods, requiring different types of solutions.

- **Spatial and temporal dynamism;**

Ecosystems and the services they provide are not homogenous across landscapes or seascapes, nor are they static phenomena. They are heterogeneous in space and evolve though time. It is precisely this feature that makes them easier to classify. Some ecosystems provide services that are utilized in the same place they were made (e.g. soil formation), whilst others whose benefits occur in another location at another time, then when and where they were provided (e.g. water regulation).

- **Joint production;**

Ecosystem services can provide multiple benefits for human welfare, which are considered 'joint products' (Daily, 1997b). Interactions among intermediate services lead to final services that provide joint products, or multiple benefits. This feature could be of real importance in certain decision-making contexts.

- **Complexity;**

Ecosystems are not linear, but complex systems, with feedbacks, time lags and nested phenomena (Limburg *et al.*, 2002). Complexity is responsible for the early classification of goods as well as for the impossibility of direct measurement and monitoring. The role of biodiversity in the production of ecosystem services is reined by uncertainty and complexity.

As the term itself has been approached in different ways, the complexity of a system is a characteristic that might actually help in classifying ecosystem services, as well as in developing financial or market mechanisms for managing ecosystems.

- **Benefit dependence.**

Services are mostly benefit dependent (Boyd and Banzhaf, 2007), allowing the benefit to dictate the way the service is valued, monitored or measured. Stakeholders and individuals perceive different benefits from the same ecosystem processes that might even turn out conflicting (Turner *et al.*, 2003).

2.2.2. Which are the services?

So far, environment experts have identified four kinds of services, all of them vital to human health and well-being. However, there might yet be important services there are still unidentified.

- **Provisioning services** - supply the good themselves, such as food, fresh water, timber and fiber, fuel;
- **Regulating services** - govern climate and rainfall, water (flooding), waste, and spread of disease;
- **Cultural services** – beauty, inspiration, education and recreation that contribute to spiritual welfare;
- **Supporting services** - soil formation, photosynthesis and nutrient cycling that underpin growth and production.

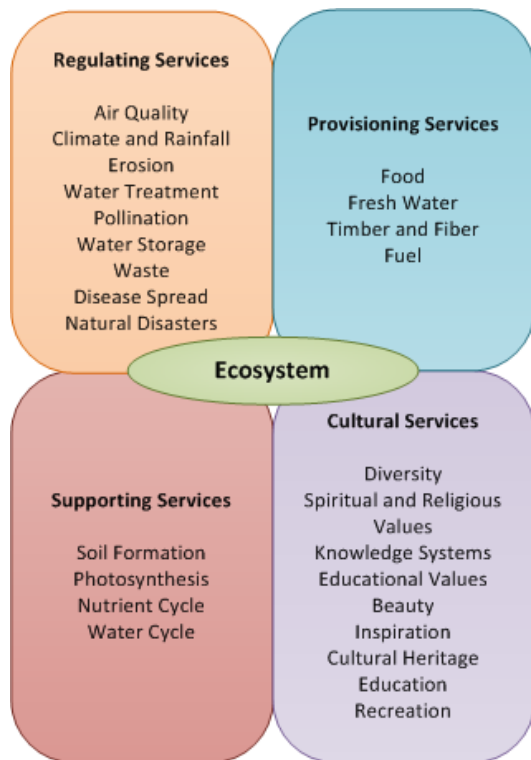


Figure 2.1. Ecosystem services

Efforts to classify ecosystem services have been considerably hindered by and their innate characteristics as well as by the dynamic complexity of ecosystem processes. It has been, therefore, quite difficult to agree upon a single or fundamental classification system. The broad spectrum of processes which lead to social choice was also crucial for mobilizing the ecosystem services concept.

The MEA (2005) focused on the public's understanding and education of the services and benefits that well-functioning ecosystems provide to humans, fact that helped in the release of the classification presented above.

The classification is understandable as it uses the complexity characteristic of ecosystems and the public-private dynamic to distinct the boundaries.

2.2.3. Which are the functions?

Ecosystem functions are defined as being '*the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly*' (De Groot, 1992). Like other concepts in the ecological literature, this term has also been subject to various and contradictory interpretations. It has been approached as the internal functioning of the ecosystem, as well as the benefits derived by humans from ecosystems' properties and processes. De Groot *et al.* (2002), researchers in Centers for Environmental Studies at top universities in Europe and the United States of America state that functions are in fact a result of the natural processes (result of complex interactions between biotic and abiotic components of ecosystems) of the total ecological sub-system they belong to. They were also the ones who proposed their assortment in four primary categories. In all, there are about 23 functions agreed upon, and a series of underlying ecological structures and processes. One function may influence the

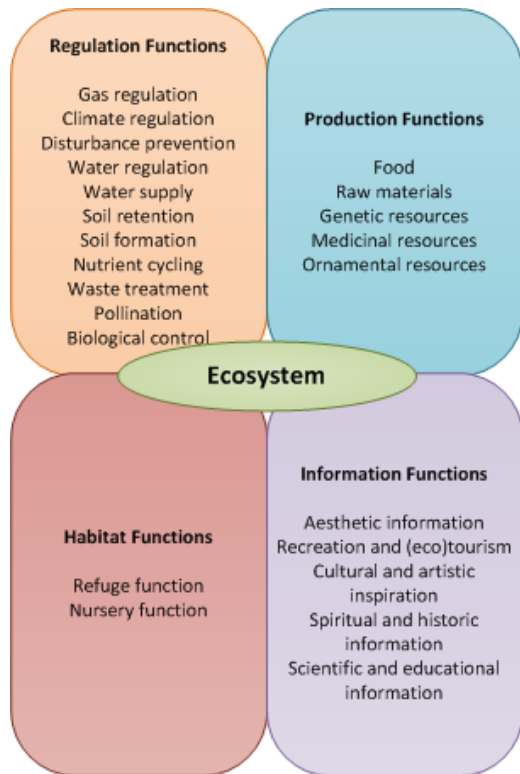


Figure 2.2. Ecosystem functions

availability of other functions, their goods and services, in a sustainable manner (Limburg *et al.*, 2002), requiring an explicit representation of their interdependencies and implications, for a better dynamic modeling (Boumans *et al.*, 2002). Moreover, ecosystem processes and services don't provide a one-to-one correspondence and their analysis involves both a physical scale (of the ecosystem function itself) and one at which the provided goods and services are valued by humans.

- **Regulation functions** - capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through a series of bio-geochemical

cycles and biosphere processes. They ensure the transformation of energy, from solar radiation into biomass, storage and transfer of minerals and energy in food chains, mineralization of organic matter in soils and sediments, regulation of the physical climate system - all of which are regulated, in turn, by the interplay of abiotic factors;

- **Gas regulation** - maintaining the chemical balance in the atmosphere, preventing diseases and any other alterations that might have uncalled for impacts on natural, social and economic processes. Analyses for determining the service value should be carried out at a considerable scale;
- **Climate regulation** - maintaining a favorable climate, at local and global scales, considering the interaction of circulation patterns with topography, vegetation and land configuration;
- **Disturbance prevention** - providing safety of human life and constructions, by ameliorating potential hazards and disruptive natural events (storms, floods, droughts etc.);

- **Water regulation** - ensuring a regular distribution of hydrological flows at earth surface, helping in the maintenance of normal conditions in the watershed.
- **Water supply** - water filtering, retention and storage performed by the vegetation cover and soil, topography and sub-surface characteristics, depending as well on ecosystems' hydrologic cycles;
- **Soil retention** - consisting of structural aspects of ecosystems, such as vegetation cover and root system, in order to maintain agricultural productivity and prevent soil erosion damage;
- **Soil formation** - maintaining crop productivity on cultivated lands together with the integrity and functioning of natural ecosystems²;
- **Nutrient cycling** - at both local and global scale, is performed by soil organisms and migrating animals, releasing nutrients to plant growth and surrounding atmosphere, respectively distributing them between ecosystems³;
- **Waste treatment** - storing and recycling organic and inorganic human waste through dilution, assimilation and chemical re-composition;
- **Pollination** - provided by wild pollinator-species (insects, birds and bats) in order to avoid extinction and to sustain current agricultural productivity⁴;
- **Biological control** - according to Ehrlich (1985), biotic communities of ecosystems participate in more than 95% in the prevention of the outbreak of pests and diseases.
- **Habitat functions** - maintaining a healthy refuge and reproduction habitat to wild plants and animals, contributing to the conservation of biological and genetic diversity;

² Soil formation is a very slow process, generating naturally at a rate of a few centimeters per century, and after erosion (regeneration), one centimeter in 100-140 years (Pimentel and Wilson, 1997).

³ Life on Earth depends on the continuous (re)cycling of about 30-40 of the 90 occurring chemical elements. Most important nutrients are carbon, oxygen, hydrogen, nitrogen, sulfur and phosphorous. Together with macro-nutrients like calcium, magnesium, potassium, sodium, chlorine and trace elements (iron, zinc), they are needed for life maintenance, but their availability is often limited, making their (re)cycling essential (De Groot *et al.*, 2002).

⁴ In the absence of wild pollinator species, agricultural productivity can only be maintained through artificial pollination, at a high cost (Daily, 1997).

- **Refuge function** - providing a 'storehouse' of genetic information, for resident and transient species of plants and animals, maintaining the viability of a 'genetic library' of Earth species (De Groot *et al.*, 2002);
- **Nursery function** - supplying breeding and nursery areas to adult species that harvest elsewhere for subsistence and commercial purposes⁵.
- **Production functions** - broad diversity of carbohydrate structures used by secondary producers for creating a larger variety of living biomass, which provides a high range of ecosystem goods for human consumption (food, raw materials, energy sources, genetic material)⁶;
 - **Food** - includes an unlimited source of edible plants and animals, as well as small-scale subsistence farming and aquaculture, whose functions need to be maintained in order to recover in a certain period of time;
 - **Raw materials** - refer exclusively to renewable biotic sources, such as wood and strong fibers, biochemical and biodynamic compounds, as well as other energy sources like fuel wood, organic matter, animal power and biochemicals, and animal-feed;
 - **Genetic resources** - cross-breeding inputs between wild and cultivated varieties of important crop-species, along with complicated manipulations of genetic resources through biotechnological research and genetic engineering⁷;
 - **Medicinal resources** - providing chemicals with use in pharmaceuticals industry, and animals for testing new medicines or as student specimens;
 - **Ornamental resources** - extensive and varied use for clothing, handicrafts, objects of worship, decoration, as well as zoological and botanical gardens collection supplements.

⁵ Certain nursery areas are often transformed to direct economic use, with disastrous ecological and socio-economic consequences (Gilbert and Janssen, 1997).

⁶ It is essential to distinct biotic resources from abiotic ones that mainly differ on their renewability. However, authors limit production functions to renewable natural resources (De Groot *et al.*, 2002).

⁷ In order to maintain their commercial status, important crops need the genetic support of their wilder relatives. Features like taste, resistance to pests and diseases, adaptation to environmental conditions are improved by the share of regular inputs of genetic material from their wild relatives and primitive (semi-) domesticated ancestors (Oldfield, 1984).

- **Information functions** - contribution to the maintenance of human health, through opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience⁸;
 - **Aesthetic information** - natural areas and landscapes scenery with great influence on real estate prices, houses' prices rising considerably in the proximity of natural parks or aesthetically pleasing environments (Costanza *et al.*, 2007);
 - **Recreation and (eco)tourism** - retreat for rest, relaxation, refreshment and recreation, ensuring a variety of recreational activities, in ongoing development;
 - **Cultural and artistic inspiration** - embedding human culture within natural systems⁹ and using nature as a motive and inspiration source for various areas, of which, people are still not aware and whose economic value is not yet appreciated aright;
 - **Spiritual and historic information** - ethical, religious and heritage-values that support the continuity and understanding of life in the universe;
 - **Scientific and educational information** - nature study and environmental education for scientific research and reference for changes monitoring.

Unfamiliarity with the ecosystem functions concept entails a restricted knowledge or ecosystem functioning. The confronting approaches exist between a descriptive interpretation and a normative interpretation (Whigham, 1996). The first one regards the ecosystem phenomenon as a contribution to something else, while in the second one, ecosystem function is perceived as an environmental value, a source of ecosystem benefits in social and/or economic terms. However, in recent literature, the most common used interpretation is the descriptive one (Whigham, 1996, Costanza *et al.*, 1997, Freeman, 1998, Heal *et al.*, 2005). This fact has implied a translation into normative concepts of ecosystem goods and services, as long as human needs or values are affected

⁸ '...natural environments provide a highly inspirational and educative form of re-creative experience, with opportunities for reflection, spiritual enrichment and cognitive development through exposure to life processes and natural systems' (Forster, 1973).

⁹ 'There is hardly any province of culture to which nature does not give shape or inspiration.' (Van Dieren and Hummelinck, 1979)

(De Groot *et al.*, 2002), thus focusing valuation nearly exclusively on ecosystem services (MEA, 2005; Alcamo *et al.*, 2003; Toman, 1996; Heal *et al.*, 2005).

2.3. Littoral ecosystems

Considered to be one of the most productive marine zones, littoral ecosystems feature high levels of light intensity, relatively high temperatures, and both macro and micro algae. A large number of species of fish and invertebrates are attracted to the coastal zones, where they find rich feeding and, frequently, breeding grounds. Distinguished as biodiversity hotspots, they support a large amount of species of macroscopic marine organisms, due to the paleogeographic, hydrological and ecological characteristics.

Due to their close proximity to cities and villages, littoral ecosystems often are affected by anthropogenic activities more than any other marine habitats. More than any other threat, littoral ecosystems face physical disturbances caused by trawling and anchoring, leading to the loss of important habitats.

Eutrophication and pollution from untreated sewage outlets and fish-farm effluents can smother benthic species and reduce water visibility, decreasing the depth to which photosynthetic organisms can survive. The accumulation of toxic chemicals in the water column can inhibit growth rates and bio-accumulates in the food chain. Mercury is a heavy metal commonly found in a number of commercial fish species, such as swordfish and tuna. These chemicals bio-accumulate throughout the food chain and can be particularly dangerous to wildlife and humans, especially to fetuses, infants, and nursing mothers.

Climate change alters seawater temperature and deep-water currents, affecting the spread of some species, with more tolerant species able to survive while fragile, slow growing species are wiped out. It can also lead to a rise in sea levels, resulting in the migration of both invertebrate and algae species further up the littoral zone.

2.3.1. Coastal areas

Represented as a transitional area between land and sea, the coastal area appears like a band whose width is determined by the interaction of marine and terrestrial coastal processes. With a worldwide average of 60 km width and less than 15% of the Earth's terrestrial surface, it accommodates however more than 60% of the world's population. Coastal areas are marked by above-average concentrations of people and economic activity, only 40% of their total surface being inhabited.

Pollution and development are affecting coastal habitats considerably. Feeding and nursery areas are being destroyed, reducing fish and wildlife populations. Runoff along the coasts leads to oxygen-depleted water and fish kills, due to the enriched content of nutrients. However, the most important sources of coastal pollution are sewage disposal and sedimentation from land-clearing and erosion. Contamination is also caused by nonpoint-source pollution that results in outbreaks of toxic algal blooms and red tides.

Global warming's effects point out both immediate and far-reaching consequences, the most direct threat to the coastal areas being the rise in sea levels. On the long run, this is the cause of frequent floods. Warm surface water temperatures also result in coral bleaching.

Being mostly populated because of their potential in fertile soil, fishing and shipping industry opportunities, coastal wetlands are lost considerably because of commercial and residential developments.

Integrated analyses of coastal areas have agreed upon the fact that coastal marine ecosystems are at risk worldwide as a result of human activities. The main key land-based drivers of ecological change were considered to be:

- Nutrient input from agriculture in urban settings;
- Organic pollutants derived from pesticides;
- Inorganic pollutants from urban runoff;
- Direct impact of human populations on coastal marine habitats.

However, only 90% of the coastal waters experience impact from human inland activities, drawing attention towards activities in the ocean, like: fishing, climate change, invasive species and commercial shipping.

2.3.2. Estuary areas

Partially enclosed bodies of water where fresh water from rivers or streams mingles with salty ocean water, estuaries trap nutrients and sediment that is carried from the land by rivers and from the ocean by tides. Being characterized by a constant mixing of these nutrients with the rise and fall of the tide, they provide an enormous amount of plant and animal life. Estuaries are therefore one of the most productive types of ecosystems on earth. Estuaries can be found in flat river deltas or steep-sided coastal fiords, being composed by tidal mud flats, lagoons, salt marshes and sand dunes. Estuaries are also popular places for people, and unfortunately many of them have been lost due to urban and agricultural development.

Estuaries formation started after the most recent glaciation (~29,000 to 10,000 years ago), when melting ice caused a rise in the sea level. Valleys that were previously carved out by glaciers and/or streams were flooded, and shallow, protected inlets and estuaries were created. An important role is also played by the sediments carried by streams and rivers, due to natural or human-caused erosion of streams and upland areas. When the water reaches the ocean and is no longer constricted in the stream channel, it slows down, and the sediment drops out. Protected from waves scouring, sediments can also form mud flats, trapped by specific vegetation, such as eelgrass and salt marsh grasses. Salt marsh grasses themselves add organic material, and may eventually form a dense mat of vegetation that is laced with tidal canals. Thus an estuary can have many forms, and is in constant change, though still depending on the pre-existing form of the surrounding landscape and specific controlling forces, like tides, wind, waves, and currents.¹⁰

¹⁰ Capital Regional District <http://www.crd.bc.ca/>

Ecosystem services provided by estuaries have long been overlooked and they were recognized only after they were “reclaimed” for human use. The way population benefits from estuaries, is being exemplified as follows:

- **Erosion control and storm surge protection** - Vegetation in estuaries anchors sediment and soil along river banks and shorelines, preventing stream flows, rainwater and waves from scouring away the land. Deposits of mud, silt and sand help to dissipate the energy of large waves that can otherwise inflict serious damage on human life and property;
- **Water quality** - Natural water is filtered by vegetation and fine sediments as it flows from the land to the ocean. Bacteria living in the sediments of estuaries can also help to break down certain pollutants;
- **Atmospheric gas regulation** - Carbon dioxide is absorbed in the photosynthesis carried out by the prolific plant growth and being released when wood or fossil fuel is burned, or when estuaries are filled in;
- **Nutrient cycling** - Concentrations of nutrients such as nitrogen and phosphorous found in the marine environment are regulated through estuaries. They are needed for plant growth but in excess can cause harmful algae blooms and rob the water of oxygen;
- **Habitat for plants, shorebirds & other animals** - Many species of animals spend all or a part of their lives in estuaries, having direct commercial value or being an important part of the overall function of the ecosystem;
- **Education, recreation & tourism opportunities** - Peaceful and beautiful landscapes, estuaries are considered proper study and teaching environments, attracting a great number of artists, canoeists, bird/wildlife watchers, hunters, fishers, photographers, scientists and researchers.

Valuable and biologically productive ecosystems, estuaries are difficult to be attached monetary worth, as most of their services are needed for life on earth and are not replaceable with human-made systems, at any cost. Estimating their real value is useful for making the appropriate land use decisions.

Estuaries are mainly threatened by urban and agricultural development. Practiced in rich soils of floodplains and estuaries for a long time, modern agriculture methods that involve diking, damming and filling-in estuaries have been severely affecting the ecological function of the land. Restoration efforts are yet unfeasible in some areas, where estuarine areas have been heavily altered by bringing forth large urban areas.

Poor water quality, caused by excess sediment, nutrients or chemical pollution, is also affecting estuaries. Logging and construction in watersheds can cause erosion and deposition of excess sediment, meanwhile fertilizers or sewage in the water can cause excess nutrient levels. Natural flows of water and nutrients are also altered by invasive species, decreasing with time, the estuaries' biodiversity.¹¹

2.4. Which are the ecosystems' values?

Nunes and Bergh (2001) where the ones to develop a different classification of biodiversity values, that doesn't necessarily imply a distinction between services and functions. According to them, '*functional diversity*' includes '*primary ecosystem processes*' (photosynthesis and biogeochemical cycling) and '*ecosystem life support functions*', as referred to in the list of ecosystem services (Heal *et al.*, 2005).

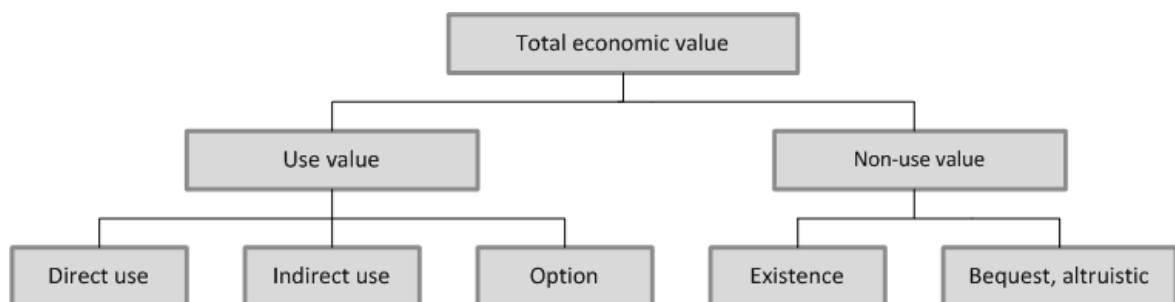


Figure 2.3. Total economic value and its components
(Source: European Environment Agency, 2010)

In the scientific papers of Farber *et al.* (2002), Limburg *et al.* (2002), Howarth and Farber (2002), Wilson and Howarth (2002), the value of ecosystem is divided into three concepts: ecological, socio-cultural and economic value.

¹¹ Capital Regional District <http://www.crd.bc.ca/>

Ecological criteria, like integrity, resilience and resistance determine sustainability limits of the ecosystems' capacity to provide goods and services. As functions and processes are inter-linked, sustainable use limits will also be determined under complex system conditions (Limburg *et al.*, 2002).

Social reasons play an important in identifying environmental functions, emphasizing physical and mental health, education, cultural diversity and identity, freedom and spiritual values (English Nature, 1994).

Economic valuation types divide into four distinct categories, with specific measurement issues:

- **Direct market valuation** - ecosystem services' exchange value in trade; applicable to goods, as well as to information functions;
- **Indirect market valuation** - implies a variety of valuation techniques to establish Willingness to Pay (WTP) or Willingness to Accept (WTA) compensation.
 - Avoided Cost (AC) - allow society to avoid incurred expenses in the absence of certain services;
 - Replacement Cost (RC) - replace services with human-made systems;
 - Factor Income (FI) - ecosystem services enhancing incomes;
 - Travel Cost (TC) - reflect the implied value of the service;
 - Hedonic Pricing (HP) - reflects the service demand in the associated price.
- **Contingent valuation** - a survey-based method, whose name comes precisely from the fact that people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service;
- **Group valuation** - derives from social and political theory, and is based mainly on principles of democracy and the assumption that the public can make resulting decisions, from open public debate (Jacobs, 1997, Sagoff, 1998, Wilson and Howarth, 2002).

2.5. Ecosystem Services Framework

Ecosystems generate a stream of vital life-support services, making their evaluation and investment a careful process. According to Turner *et al.* (2007), the Ecosystem Services Framework (ESF) has encountered various challenges in its way to operability:

- Detailed information for decision-making purposes;
- Practical design & implementation know-how;
- Compelling models of success, aligning economic aspects with conservation.

The ESF highlights the long-term role that healthy ecosystems play in the sustainable provision of human wellbeing, economic development and poverty alleviation around the world (Turner *et al.*, 2008). Climate stabilization, drinking water supply, flood alleviation, crop pollination, recreation opportunities and amenity, as well as other cultural assets need to be sustainably provisioned by means of an efficient and effective management of ecosystems (Westman, 1977, Holdren and Ehrlich, 1974, Daily 1997, Balmford *et al.*, 2002, Turner *et al.*, 2003, MEA, 2005). Provided goods and services are both private and public, with a different availability in time and space, bringing a wide range of benefits to human welfare. Moreover, they are linked to (and detained by) a series of property rights and institutional arrangements. A complexity of factors like type and scale of provided ecosystem service, stakeholders mix, socio-economic characteristics and socio-cultural context, ensures a cover of efficiency and effectiveness criteria, alongside equity, ethics, justice and legitimacy over the political economy of ecosystem conservation (Adger *et al.*, 2001, Paavola, 2005).

Nowadays, intensifying pressure on depleting natural resources make traditional arguments of ecosystem conservation seem effective less and no longer hinge human well-being upon natural capital. However, conservation's global-level recognition mostly makes economic sense for the society; therefore individuals, as well as governments provide insufficient finance to match the conservation rhetoric (Pearce, 2007). As a result, wild habitats and populations are declining yearly, by an average of 0.5-1%, with pronounced losses in the developing world (Balmford *et al.*, 2002). In order to reverse this

trend, the adoption of a complete ecosystem services-based decision support process will analyze and synthesize relevant knowledge and capture ecosystem services' benefits.

The framework considers a comprehensive analytical and practical process, starting by identifying the problem/issue, and aiming to outline and quantify ecosystem service provision, as well as social, economic and politico-cultural contexts. The next step consists of modelling, mapping and valuing the chosen ecosystems and services. Sustainable management of resources needs to be ensured by practical and inclusionary payment mechanisms, as implied by some of the goods' characteristics.

However, a series of constraints occur, as stated by Turner *et al.*, (2007):

- Information failure - Lacking information on how people actually benefit from specific services, thus making conservation investment finance low and ineffective;
- Institutional failure - Insufficient consideration to property rights and institutions, as beneficiaries of ecosystem service provision are often different and distant from the ones who gain from ecosystem transformation;
- Market failure - Determined by good's characteristics and their lack of prices, as well as by short-term valuation of natural resources, neglecting long-term ecological health and human welfare.

Ecosystem services are regarded as a linkage route towards sustainable development. The fact was approached by two means, as a contribution to both nature conservation and sustainable development. Related to the first accept it is notable that funds can be used in order to compensate potentially lost economic opportunities. Ecosystem services need a better accounting and understanding of the rates at which they are produced for a better payment motivation for nature conservation. Explicitly quantified benefits are more valued, both by people who usually interact with them, as well as by government and interested agencies, which would normally have to pay for their substitution, in the case of potential damage. This approach is qualified as '*government investment*', because payments come from beneficiaries outside the local area, and it is precisely government's and agencies' role to collect and redistribute the funds (Tallis *et al.*, 2008).

Secondly, maintenance of ecosystem services involves an improvement of nature conservation projects, as well as of local producers' welfare, by fostering markets for their extracted and produced ecosystem goods and services. These 'community-based' projects enhance better protection of local ecosystems.

In the case of endangered value of ecosystem services, governments invest in their protection. The money used for this purpose is usually obtained from charging beneficiaries for the use of ecosystem services. Thereafter, ecosystem services are used for the motivation of payment for nature conservation.

Conservation of ecosystem services has also been aligned with local economic activity, by the integration of conservation and development using eco-tourism. By these means, a market-based income has been obtained, for there are corporations and other private

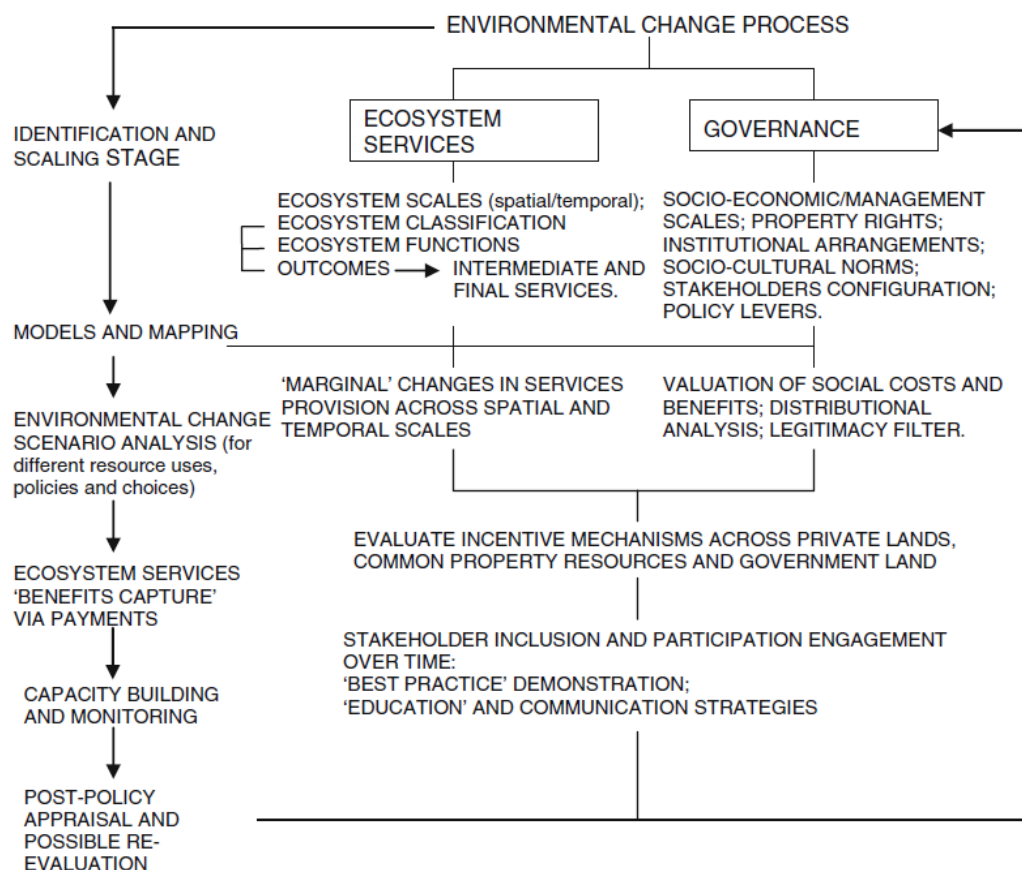


Figure 2.4. The Ecosystem Services Framework (ESF) (Source: Turner *et al.*, 2008)

sector components that invest in projects of the kind. However, failures are also quite common. 16% of 194 Implementation Completion Reports for World Bank projects had an unsatisfactory or highly unsatisfactory overall performance, due to political or economic factors outside the control of the project.

Accounting for final environmental services is of great importance to public policy because services contribute significantly to human welfare and are not captured in existing welfare accounts. Accounting from an economic perspective requires also an economic derived definition of ecosystem services. This would employ two fundamental insights. First of all, ecosystem services should be isolated from non-ecological contributions to final goods and services, because by combining them with other inputs, such as labor or capital, the cease in being identified as 'ecological'. Secondly, economic accounting is concerned with ecological end-products, not the far larger set of intermediate processes and elements that make up nature (Boyd and Banzhaf, 2007).

2.6. Payments for Environmental Services (PES)

Payments for environmental services are mechanisms that deal with the mismanagement of ecosystems, relying on the fact that many of their benefits are considered externalities from ecosystem managers' perspective. Their ambit is in achieving environmental objectives, as well as human welfare. However, the concept of PES covers rather any kind of market-based mechanism for conservation. The principles commonly applied in field works as drawn by Wunder (2005) are:

1. A voluntary transaction where
2. A well-defined environmental service (or a land use likely to secure that service)
3. Is being 'bought' by a (minimum one) service buyer
4. From a (minimum one) service provider
5. If and only if the service provider secures service provision (conditionality).

PES is also appreciated to internalize what would otherwise be an externality (Pagiola and Platais, 2007), making conservation the most attractive option for ecosystem managers.

Implementation of PES also stands in the services' attributes, of being public goods or not.

PES programs differ according to a series of characteristics, among which the issue of who the purchasers of the environmental services are. They may therefore be actual users of the services or other entities, such as the government, NGOs, or international agencies. The latter have no first-hand information, as they are not direct users. The distinction stands in who has the authority to make decision about allowing payments, and not in who is making them (Engel *et al.*, 2008). As Rojahn and Engel (2005) have stated, potential sellers of environmental services can be landholders, governments, as well as local communities with joint property rights in safeguarding their delivery.

Table 2.1. - Indirect, option and non-use values associated with environmental services

	Indirect use value	Option value	Non-use value
Off-site Local Benefits	Watershed, soil and flood protection: <ul style="list-style-type: none"> • Water quality • Water and nutrient recycling • Soil fertility • Pest and disease resistance • Aesthetic, cultural and spiritual values 	Conservation of ecosystem biodiversity for potential future uses	Aesthetic, cultural and spiritual values
Global Benefits	Climate change mitigation	Genetic material which can be used for agricultural, medical and other future purposes	Biodiversity conservation and species preservation

Source: FAO, 2007

The same authors define the mechanism of PES as one in which an environmental service buyer offers a payment to an environmental service seller who undertakes an activity in the benefit of the buyer. Essential elements in assessing the potential demand of environmental services and identifying buyers from the list of potential beneficiaries imply the establishment of where (at local, regional or global level) and when

(immediately or into the future) the benefits from environmental services occur, and estimating their value.

Chapter III

Study Case: The Ria de Aveiro, Coastal Lagoon

3.1. Introduction

Representing an important area in the Portuguese coast, Ria de Aveiro provides natural conditions for harbor, navigation and recreation facilities. It is also considered a place of discharge of domestic and industrial wastes, offering good conditions for agricultural development along its borders and for the set-up of a large number of small and medium industries. Ria de Aveiro



Figure 3.1. Ria of Aveiro's location in Europe and Portugal

The lagoon, a very recent geological feature, has developed through marine sediment transport along the Portuguese coast and by deposition of solids carried by rivers. As these mechanisms have not yet attained equilibrium, the present tendency is to silt up. The topography of the place includes three main canals which radiate from the mouth with several branches, islands and mudflats, forming an intricate system of bays, areas of

intertidal flats and a web of narrow canals. The lagoon also comprises a large area of mostly abandoned salt pans, whose progressive degradation is caused by the lack of maintenance and by the strong currents which erode their protective walls.

Very important in the local economy, the estuarine zone of Ria de Aveiro lagoon hosts the port of Aveiro, which receives more than one thousand ships per year. Tourism has also increased in recent years, due mainly to water sports activities. Estuaries are sensible interfaces regions between upland wetlands and the coastal ocean, closely linked to ecology and biodiversity issues. Therefore, in the case of Ria de Aveiro this is particularly relevant due to the importance of the São Jacinto Dunes Natural Reserve, a well preserved dune barrier ecological system, located in the north area of the lagoon, with several ponds frequented by numerous species of local and migratory water birds (Mendes *et al.*, 2009)

3.2. Main characteristics

3.2.1. Location



Figure 3.2. Barra de Aveiro Canal

The Ria de Aveiro is a shallow water lagoon, located along the north-western coast of Portugal, from Ovar to Mira (40°38' N, 8°45' W), separated from the Atlantic Ocean by a sand dune barrier. With an irregular geometry, it is only connected with the ocean through an artificial canal (Barra de Aveiro, with 1.3 km length, 350 m width and 20 m depth), opened in the beginning of 19th century (Figure 3.2.). Reaching a maximum width of 8.5 km and extending for over 45 km, this lagoon presents a significant variable area due to the large tidal influence on its hydrodynamics. In spring tides it reaches a maximum area of 83 km² at high tide, which reduces to a minimum of 66 km² at low tide. The average depth of the Ria de Aveiro is 1 m, but deeper in the navigation canals close to its mouth and the areas contiguous to the ports, because of the constant dredging operations to allow the access

of large ships to the port. Other navigation canals, where dredging operations are frequently carried out, are about 7 m deep.

Numerical modelling of Ria de Aveiro is hence turning difficult because of the variable depth associated with the large number of narrow canals and with the existence of intertidal areas. Due to the small depth and to the significant tidal wave amplitude there are zones, especially along the borders of the lagoon and its central area, which are alternately wet and dry during each tidal cycle. The Ria de Aveiro is a coastal lagoon of decrease depth and extensive zones between tides.

The lagoon has four main branches radiating from the sea entrance: Mira, São Jacinto, Ílhavo and Espinheiro canals. The Mira canal is an elongated shallow arm, 20 km in length, receiving continuous freshwater input at its far end from a small system of ponds and rivers. Its salinity ranges from 35.1 to 0.0, according to Moreira *et al.* (1993). Water temperature (8.5-24.7°C) decreases along the canal towards its far extremity during the cold season, running an inverse and more pronounced trend during the hot season. The São Jacinto canal is about 29 km long and is the most important canal in terms of average width and length. Ílhavo canal is the narrower and shorter of the main canals, with a length of 15 km. Discharging into this canal is a small river, the Boco, of little importance in terms of freshwater input. Finally, Espinheiro is a short canal of about 17 km in length which has a complex network of small dead arms.

The lagoon can be divided in three main zones. The South zone includes the canals of Ílhavo and Mira, with 7 and respectively 14 km length, and 200 and 300 meters maximum width. The Canal of São Jacinto - Ovar in the North zone has 25 km of length. Due to its little depth in the northern extreme, this canal gives rise to a complex net of small canals and basins. The third zone, with a very complex geography, ends at the estuary of Antuã River and is known as Ria Murtosa.

Ten centuries ago, the lagoon didn't exist, the rivers being drained directly into the ocean. At that time, the development of two sand bars was initiated, one to the North in Espinho and another one to the South near Cabo Mondego. The location of the bars has varied in time between Torreira and Mira, with periods in which the lagoon was completely

isolated from the ocean. The current bar was built in 1808, being set by two breakwaters. The medium freshwater torrent that flows to the Ria is of around $40 \text{ m}^3/\text{s}$. Vouga and Antuã rivers make the main freshwater springs, with medium annual torrents of $24 \text{ m}^3/\text{s}$ and respectively $2.4 \text{ m}^3/\text{s}$. The circulation in the interior of the lagoon is dominated by the tide, whose amplitude varies between 3.3 m in spring tide and 1.0 in neap tide.

On the western coast of Portugal the wave of tide spreads from the South to the North. The tide enters the Ria through the canal of Barra and spreads in decreased speed along the canals. The maximum speeds of about 1 m/s occur in the zone of Barra, in the deeper and narrower canals. The wind's strength is more important in the less deep areas where the tide flows are very low (Dias *et al.*, 1996).

3.2.2. Biophysical

From a morphological approach, Ria de Aveiro has the characteristics of a typical bar-built estuary, having experienced incision during an ice age and subsequent flooding, attenuated at present due to recent sedimentation with material from the coastal erosion entering the lagoon mouth from the rivers.

Ria de Aveiro is a shallow vertically homogeneous lagoon, supplied with freshwater by two major rivers, Antuã and Vouga. Tides propagate from the mouth of Ria de Aveiro and are present in the entire lagoon. The tidal amplitude decreases with the distance from the mouth while the phase lag in the high and low water



Figure 3.3. View of the Ria of Aveiro

(which is different) increases. The tidal range increases for the spring tide at the far end of the canals correspond to a local increase of the high tide level, which result in a fortnightly variation of the mean levels at those places.

The lagoon is mesotidal (tidal amplitude at the inlet ranges from 0.6 m in neap tides to 3.2 m in spring tides - average 2 m) (Dias *et al.*, 2000) and the semidiurnal tides are the major factor influencing the hydrodynamics of the lagoon (Dias *et al.*, 2000).

The tide at the mouth of the lagoon is predominantly semidiurnal, with a mean tidal range of about 2.0 m. It propagates from the mouth as a mixed progressive and standing wave and is present in the entire lagoon. Tide generates strong currents in deep and narrow canals, but not in the intertidal area. The highest values are found at the beginning of Espinheiro and São Jacinto canals, and especially in the entrance canal, where the tidal current amplitude can be higher than 1 m/s (Dias *et al.*, 2000). The induced tidal residual currents are directed downstream in almost all the domain because the ebb tidal currents are higher than the flood ones in this lagoon (Dias *et al.*, 1998).

The hydrological features of Ria, were investigated in two sampling surveys carried out between 3/6 and 24/6/97 and between 29/6 and 7/7/97, respectively. Due to recent rainfalls, there was recorded a significant freshwater inflow into the lagoon during the first survey, especially in the first days. Several stations along the four canals of the lagoon have shown values concerning water level, salinity, temperature and current velocity. The type of tide at the mouth was determined and also the fact that the main forcing agent driving water circulation in Ria is astronomical tide. The tide at the mouth is semidiurnal and the tidal wave propagation in the lagoon has the characteristics of a damped progressive wave. Typical estuarine longitudinal salinity and temperature gradients connected with the distance to the mouth were identified, but unimportant vertical and transverse gradients, but from the frontal zone between oceanic and fresh water masses. Though Ria de Aveiro should be considered as vertically homogeneous, some canals may reveal characteristics of a partially mixed estuary, depending on the freshwater input.

Extreme situations of wind and freshwater forcing influence Ria de Aveiro's hydrodynamics. There are several rivers draining along the surrounding area, of which the most important are the Vouga, Antuã and Boco. Besides these, there are also some other smaller rivers that drain into the northern canals (Caster, Gonde and Fontela) and to the

Mira Canal. In spite of the complex interaction between its geomorphology, tidal effects and its tributary river drainage seasonal variability, the Ria de Aveiro can nevertheless be considered a vertically homogeneous estuarine environment during most of the year.

The major fluvial input comes from the Vouga ($50 \text{ m}^3\text{s}^{-1}$ average flow) and the Antuã rivers ($5 \text{ m}^3\text{s}^{-1}$ average flow). The Vouga River contributes around 2/3 of the fresh water entering the lagoon (Moreira *et al.*, 1993; Dias *et al.*, 1999). However, river flows into the lagoon were neglected, because the total mean fresh water discharge into the lagoon during a tidal cycle is about 1.8 mm^3 (Moreira *et al.*, 1993) while the tidal prism is 137 mm^3 for maximum spring tide and 35 mm^3 for minimum neap tide (Dias *et al.*, 2000).

The average flows of fresh water for the Vouga River and Antuã River are about $29 \text{ m}^3/\text{s}$ and $2 \text{ m}^3/\text{s}$, respectively. The total mean river discharge during a tidal cycle into the lagoon is about $1.8 \cdot 10^6 \text{ m}^3$ (Moreira *et al.*, 1993) while the tidal prism at the mouth in a spring tide with a tidal range of 2.48 m is about $70 \cdot 10^6 \text{ m}^3$ (Vicente, 1985).¹² The tidal prism in each one of the main canals relative to its value at the mouth is about 38% for São Jacinto canal, 26% for Espinheiro canal, 10% for Mira canal and 8% for Ílhavo canal. The tides at the mouth of the lagoon are predominantly semi-diurnal, with a mean tidal range of about 2.0 m. The minimum tidal range is 0.6 m (neap tides), and the maximum tidal range is about 3.2 m (spring tides), corresponding to a maximum and a minimum water level of 3.5 and 0.3 m, respectively. According to these values Ria de Aveiro is a mesotidal lagoon (Davies, 1964). It has been observed that the difference between surface and bottom salinity and temperature values is very low (Dias *et al.*, 1999). It can, therefore, be postulated that the Ria de Aveiro is a very well mixed lagoon (Pritchard, 1967).

¹² Despite its economic, social and environmental importance, no previous hydrological measurements covering the whole lagoon have been made. The most comprehensive study concerns biological and environmental research; Moreira *et al* (1993), Queiroga *et al.* and Silva performed some localized measurements of water temperature, salinity and currents.

Ria de Aveiro's growing demand for leisure activities is due to the biophysical characteristics of the area, as well as to the beauty of the landscapes. Therefore, municipalities have undertaken a series of urban interventions on the waterfronts of the lagoon. Probably the main resources for the development of leisure and recreational activities are the existing quays



Figure 3.4. Urban canals and quays of the Ria of

the lagoon. However, for the fulfillment of this aim, it is necessary to research new means of intervention in the area of coastal and lagoon integrated management (Alves *et al.*, 2001a).

Past social and economic activities developed around the Ria of Aveiro were strongly related to the conditions of navigability of the canals in the lagoon. The latter were used for passenger and goods transportation, fact that later led to the development of a system of quays on the main urban and rural waterfronts areas. Originally about 109, the quays of the lagoon currently count only 30 that are still in use or in the conditions of being re-used. The rest have either disappeared, or are in an advanced state of degradation.

The salt pans of the Ria de Aveiro occupy about 15 km². The number of active salt pans has decrease from about 500 in the 15th century, to 270 fifty years ago, and only 8 remain nowadays. The salt pans currently occupy the marsh areas, which are islands in the lagoon and only few have access by land. The salt pans in the Ria de Aveiro are divided into five groups:



Figure 3.5. Salt pans in the Ria of Aveiro

São Roque, Sul, Mar, Norte and Monte Farinha. Due to the large extension of the salt

pans of Aveiro, it was never possible to perform an integrated study of all salt pans. The most vulnerable to strong currents are the Mar group and the southern part of the Norte group (Picado *et al.*, 2009).

The Ria de Aveiro, along with the estuary of the Sado, Tejo and Ria Formosa, is one of the most important ecological humid areas in Portugal, conserving innumerable bird species, especially aquatic birds. Greatly influenced by the sea and affected by sweet water currents from the rivers, it conditions human activity in the lagoon. Sole, flounders, snooks and eels, as well as the bivalves, such as cockle, clams and mussel, still feed many coastal populations. The presence of this enormous patch of water, also conditions its weather characteristics and of the surrounding areas.

Nineteen different types of natural habitats are identified in the area, conditioning the inclusion of the Ria de Aveiro in the Natura 2000 network, a European program of organized defense of Natural Habitats. According to the list in Annex I of the Habitats Directive it includes: estuaries, lagoons, swamps, sandbanks, Atlantic salty meadows, dune forests of pinaster (maritime pine trees) and stone pine, active peat bogs, groves of ash trees, oak groves and many others. It is, therefore, not only a very important area for mammals such as the otter, but also important in the riparian formation in the interior region of the lagoon, which support an illustrious avifauna of great conservationist significance. In the autumn and winter seasons alone an estimated 10 to 15000 birds are greeted by the Ria, many of them from as far away as the north of Europe. These features make the Ria de Aveiro the most relevant humid area in the conservation of aquatic avifauna north of the Tagus River. It is presently an Avifauna Special Protection Area (ASP). Sander lings, kingfishers, ring plovers, royal terns, black-winged stilts, avocets and more recently flamingos, are only a few of the species which can be seen, during the winter months, rich in its diversity. However, the accompaniment and preservation of these diverse habitats is imperative and requires a series of action to be taken.

The Pateira of Fermentelos is considered the largest natural lagoon of the Iberian Peninsula and the second largest in Europe. It comprehends important habitats and biodiversity nucleus with special emphasis on the ornithological factor where it is possible to

observe the many bird species that can be found on the Ria de Aveiro. Its formation process took place quite possibly, at the end of the 15th century originating from an ancient inlet that ran into the Águeda and Cértima rivers, as well as the Vouga River. It is, at present, the result of the silting up and ebbing of the Cértima River, which covers an area of 5km² of variable depths and dimensions. Of the extensive list of species we could enunciate the red heron and the marsh harrier are special due to its conservationist interest.

Due to its importance it is part of the Special Protection Area of the Ria de Aveiro, greatly contributing towards the equilibrium of the areas' natural systems. It extends primarily into the county of Águeda, but also includes the counties of Oliveira do Bairro and Aveiro, representing for local populations an important differentiating element in tourism.

According to the available data, there have been identified 64 fish, 12 amphibian, 8 reptile, 173 bird and 21 mammal species in Ria de Aveiro waters (Borrego, 1996).

3.2.3. Socio-economic

The Ria de Aveiro's surface is covered by 47 districts (Angeja, Aradas, Avanca, Beduído, Bunheiro, Cacia, Canelas, Eirol, Eixo, Esgueira, Fermelã, Fonte de Angeão, Gafanha da Boa Hora, Gafanha da Encarnação, Gafanha da Nazaré, Gafanha do Carmo, Glória, Ílhavo, Mira, Murtosa, Nariz, Nossa Senhora de Fátima, Oiã, Oliveirinha, Ouca, Ovar, Palhaça, Pardilhó, Ponte de Vagos, Praia de Mira, Requeixo, Salreu, Santo André de Vagos, Santo António de Vagos, São Jacinto, São João, Sosa, Torreira, Vagos, Válega, Veiros and Vera Cruz), belonging to nine municipalities, namely: Albergaria-a-Velha, Aveiro, Estarreja, Ílhavo, Mira, Murtosa, Oliveira do Bairro, Ovar and Vagos. The area corresponds to an approximate area of 184.5 km², representing about 10% of NUTS III Lower Vouga Lagoon¹³.

¹³ The Nomenclature of Territorial Units (NUTS) for Statistics is a geocode standard for referencing the subdivisions of countries for statistical purposes. The standard is developed and regulated by the European Union, and thus only covers the member states in detail. NUTS is instrumental in European Union's Structural Fund delivery mechanisms. For each EU member country, a hierarchy of three NUTS levels is established by Eurostat.

A well-documented 10th century village, Aveiro became a town in the 12th century, thanks to its economic resources and strategic geographical importance. During the XV century, Infant D. Pedro fortified and improved the place, providing better security conditions in the trade and fishing activity. At a later date, his granddaughter, D. Joana of Portugal (who would also become the “lady of Aveiro”), abandoned her father’s (King Afonso V) court and fixed residence in this town – her own “little Lisbon” – at the Convent of Jesus, where she died in 1490. During these centuries, Aveiro established itself in the Coastal Region, attracting people due to its many and diverse activities. Among these activities were the explorations of salt and fishing, shipbuilding and nautical trade, with a strong Jewish community.

Over time, through the development of trade and fishing interests, as well as urban growth, Aveiro reached 16000 inhabitants, whose number decreased with the economic and political difficulties the town faced through the silting of the harbor entrance in Barra and the damming up of the waters. At the end of the 18th century, it counted 3500 inhabitants. In 1759, Aveiro became a city, and in 1808, the harbor entrance was rebuilt allowing a considerable industrial development, connecting Lisbon and Porto railroads.

During the 20th century, the county of Aveiro registered a population growth and global development in areas like metal mechanics and metallurgy, ceramics, paper pulp, farm products and lumber exploration. With an actual population of approximately 70000 inhabitants, Aveiro is closely linked to the Ria and to the cities of Ílhavo and Gafanha da Nazaré, which greatly contribute towards increasing its potentials. Further north, along the Ria, are Estarreja and Ovar, and more inland Santa Maria da Feira, São João da Madeira, Oliveira de Azeméis, Albergaria-a-Velha and Sever do Vouga. In the south we come across the towns, among others, of Vagos and Mira on the coast, while further inland and on a higher plateau are Águeda, Anadia and Mealhada.

More than 300 000 people live around the lagoon and its canals; this concentration in a small area brings up several environmental and pollution problems. The study of these kinds of problems must be based upon an understanding of the biological, chemical and geological processes, which are highly dependent on the lagoon’s hydrodynamics, and

implies the existence of an extensive data set concerning water quality and physical parameters.



Figure 3.6. 'Marinhas' in the Ria of Aveiro

In the region, the salt exploration began in the 20th century and developed along the following centuries, while salt pans laboring in the south of the country entered a period of crisis around the 12th century. Although an irrelevant activity in the region's economy, its activity has been maintained. The salt of Aveiro,

considered one of the best, was commercialized across the entire country and in Europe (especially in the north) and was essentially used to salt meat and fish, namely cod. The salt production techniques and its transportation haven't accompanied though the evolution of time, are still carried out in the traditional manner, from cleaning the 'marinhas' (salt pans) until its storage. It was the responsibility of the 'marnoto', the salt worker, to organise and accompany the several heavy jobs, which were carried out in the salt pans, from mid-spring until the end of autumn. The production was kept in white heaps, which, by the end of the summer, were turning grey and during the winter, it was transported to the 'palheiros' or warehouses. Later, the centre of this activity moved to the São Roque Canal, where some of the ruins are still visible.

Despite the exploration of salt, one of the most important economic activities of Aveiro lays within the fishing sector. The ancestral fishing was centralized in the lagoon area, and after many years, evolved into open sea fishing. Over the decades, the town's inhabitants have dedicated themselves to short and medium term coastal fishing, and not only. It was also here that fishing for codfish and other large fish specimens in the North Sea began. This activity shaped the region's people and customs, which are still reflected in



Figure 3.7. Salt exploration in the Ria of Aveiro

today's economy and gastronomy, as well as navigation skills. All this sea-linked activity has accompanied the growing importance in Nautical Trade with an increase in product diversity exported by the Port of Aveiro which is very well equipped and has adequate infra-structures. An example of this evolution is the railroad connection to the Commercial Port, which allows an increase in diversity and quantity of articles exported via this route.

The Portuguese discovered the value of codfish during the 15th century because it was suitable for their needs during the long periods they spent at sea. Cod is capable of preserving its qualities once it has been salted. After several test trials with other fishing species, the Portuguese elected the cod when they identified it near the North Pole, on the coast of Newfoundland. Resistant and affordable by people, who normally couldn't buy fresh fish, its taste was better than that of any other salted fish. In a time when the Christian faith greatly fomented the consumption of fish because it was "cold food" in detriment of "hot food" (red meat), the consumption of cod was extremely encouraged by traders as a substitute for forbidden food. The cod became greatly connected to the culture of the Portuguese people, rapidly becoming a pillar in national gastronomy. At a later date, in 1935, trawl fishing began with the 'Santa Joana' ship (built by Carlos Roeder in Denmark), thus liberating the fishermen from the harsh working conditions to which they were subjected aboard the old vessels. At the moment, Portugal is the world's main consumer of codfish, with hundreds of recipes in its cuisine.

The Xávega art is an endangered traditional fishing method, which is still carried out in the region of Aveiro, at the Vagueira and Furadouro Beaches. It is a different type of trawl fishing due to the fact that the boat exits to land with a rope tied to it. It goes out about 500 meters from the coast and starts circling leaving behind the net which is then dragged onto the shore and pulled by oxen that are currently aided by tractors. Thus, the net brings in the fish caught along the way, and spreads it on the beach.

Up until the mid-20th century, a great part of the socio-economical activities of the Region were closely connected to the Ria, which demanded great diversity with regards to the acquisition of adequate vessels for its different



Figure 3.8. Traditional boats in the Ria of Aveiro

activities. Besides the traditional farming activities, there was the production, storage and commercialization of salt, high-sea and river fishing, as well as the transportation of people and merchandise in general. This is how the 'moliceiros', used for gathering 'moliço' (existing riverbed algae), the 'mercantéis' for transporting goods in general, and the 'bateiras' for fishing and hunting in these swamped regions, originated.

Aveiro Port, considered one of the most modern port infrastructures in Portugal, was developed between 2000 and 2006. It has shown remarkable vitality in the substantial traffic growth and in a steady increase in the diversification level of products being transferred, namely the container segment.



Figure 3.9. The Aveiro Port

With an annual traffic of approximately 4 million tons and an average annual growth considerably superior to that of the national average, it became the main Portuguese port in the transportation of metallurgical products and is highly proficient in the transportation of fraction cargo. It is, at present, a multifunctional port, with a major role in providing services to the main industrial sectors of the region, such as ceramics, chemistry, wine, metallurgic, lumber and by-products, food, construction and automobile.

The Logistic Platform of the Aveiro Port is presently integrated in the national network of logistic platforms, Portugal Logístico, which will allow for long-term storage operations and other logistic and industrial activities. Due to the fact that it is the nearest Port to Madrid, it is located in the center of an important communication axle, with excellent motorway and railroad access. The absence of urban pressure, good security systems and environmental practices also favor its activity. Presently situated in an outstanding position due to its significant accosting capacity, which is one of the largest in the country, the port offers its potential investors a large leveled ground area for the implementation of logistic and industrial activities.

The railroad connection to the Aveiro Port and the new harbor entrance will enhance its position within the Iberian framework, reasserting Aveiro as one of the most competitive multimodal logistic junctures of the center of Portugal and of the Iberian Peninsula.

The harbor entrance is indicated by the presence of the 'Barra Lighthouse', the tallest in Portugal, and one of the tallest in the world. It was built between 1885 and 1893 and cost, at the time, 51.000 'escudos'. Its main source of light was obtained through the incandescence vapor of petrol. Although it was electrified in 1936, the electrical lighting system only became operative in 1950. Although it currently has an elevator, it is still possible to climb the snail-shaped staircase, made up of 271 stone steps in the 1st sector followed by a 2nd metallic sector with 20 steps. The luminous projector is fixed at a height of 62 m (66 m above sea level), and in normal atmospheric visibility conditions can reach a distance of 26 nautical miles, approximately 42 km, intercepting the lighthouses of Figueira da Foz and Leça da Palmeira. Without the lighthouse, the ships would frequently be attracted to land, due to the illusion of distance, caused by a very flat coastline with the first elevations quite far from the sea.

3.2.4. The Ria de Aveiro's surroundings

São Jacinto is a small town isolated in a peninsula between the sea and the Ria with a little over 1000 residents. It had its greatest population and economic growth during the height of cod fishing in Portugal, with the installation of the São Jacinto Shipping Yards, and of a huge drying area for this fish. Nowadays, the shipping yards are practically



Figure 3.10. São Jacinto Dunes Natural

abandoned and, due to the industrial drying process system, the traditional drying method is practically non-existent. Travelling to Aveiro is done daily by ferryboat, or by land, through the north in the direction of Estarreja. Its history is associated with the Military Base founded in 1917, at the end of World War I for anti-submarine hydroplanes, under the co-ordination of the French Navy. At the end of the war, it became a Portuguese Naval Aircraft Base and in 1927 the 'Admiral Gago Coutinho' Naval Aviation School was opened here. Subsequently, a landing strip was built which allowed conventional aircraft, besides the hydroplanes, to operate. A paratrooper's base was integrated in this unit in 1978 together with the military aerodrome. In 1993 the paratrooper's base came under the tutelage of the Army and was given the name of São Jacinto Military Area. Presently, the military base has been deactivated and replaced by the Aveiro Municipal Aerodrome for civilian use.

Costa Nova originated with a small group of fishermen and was built on a narrow sandy coastal cord between the Atlantic and the Ria de Aveiro, with less than one kilometer in width and constantly threatened by the sea. With narrow streets and stairways and buildings with ground and first floor only, the town is mostly known because of the small wood-built colorful fishermen houses. The town was founded, quite possibly, in the beginning of the 19th century, when the harbor entrance was opened (in 1808), due to the fact that this nautical construction forced the fishermen from São Jacinto who practiced the Xávega art, to move south of the harbor. Therefore, their residences were

fixed opposite Gafanha da Encarnação, where a vast green area existed and they named it the town of Costa Nova do Prado (nova (new), in relation to 'costa velha' (old coast) at São Jacinto, and Prado for its green area). The original lofts in Costa Nova, built with overlapping boards of wood and covered with straw or canes designed for



Figure 3.11. Fishermen houses in Costa Nova

sheltering tools used for gathering seaweed and fishing, gave way to regular residential or holiday houses. The town's popularity among tourists started in the mid-1800's and is nowadays an excellent attraction during summer months and not only.

Other towns, like the Gafanhas, Murtosa, Torreira, Vagueira and Mira, are also bathed by the Ria and draw economic benefits thanks to it. This is achieved through the traditional fishing in the lagoon or farming and cattle rising, by the banks and recently, also due to the rising tourist interest.

3.2.5. Planning and Governance

The Administration of the Hydrographic Region of the Center, I.P. (ARH Centro, I.P.) is a public institute integrated in the indirect administration of the State, under the guardianship of the Ministry of Environment, Territorial Planning and Regional Development, whose mission is *'to protect and to value the ambient components of the water and to promote the sustainable management of the water resources'* in the context of its area of jurisdiction that encloses the hydrographic basins of Vouga, Mondego and Lis rivers, the coastal line and associated underground water masses.

As well as the four other existing administrations of hydrographic regions in the country, the ARH Centro sets up an organism resulting from a deep reorganization of the institutional model of management of the water resources, accommodated within the Water Law (Law 58/2005 of the 29th of December). It has under its responsibility, in

conjunction with its counterparts and the National Authority of Water, the integrated management of the inland and coastal water resources, namely, the planning, licensing, inspection, requalification of the hydrographic network and monitoring of the water resources in its area of jurisdiction.

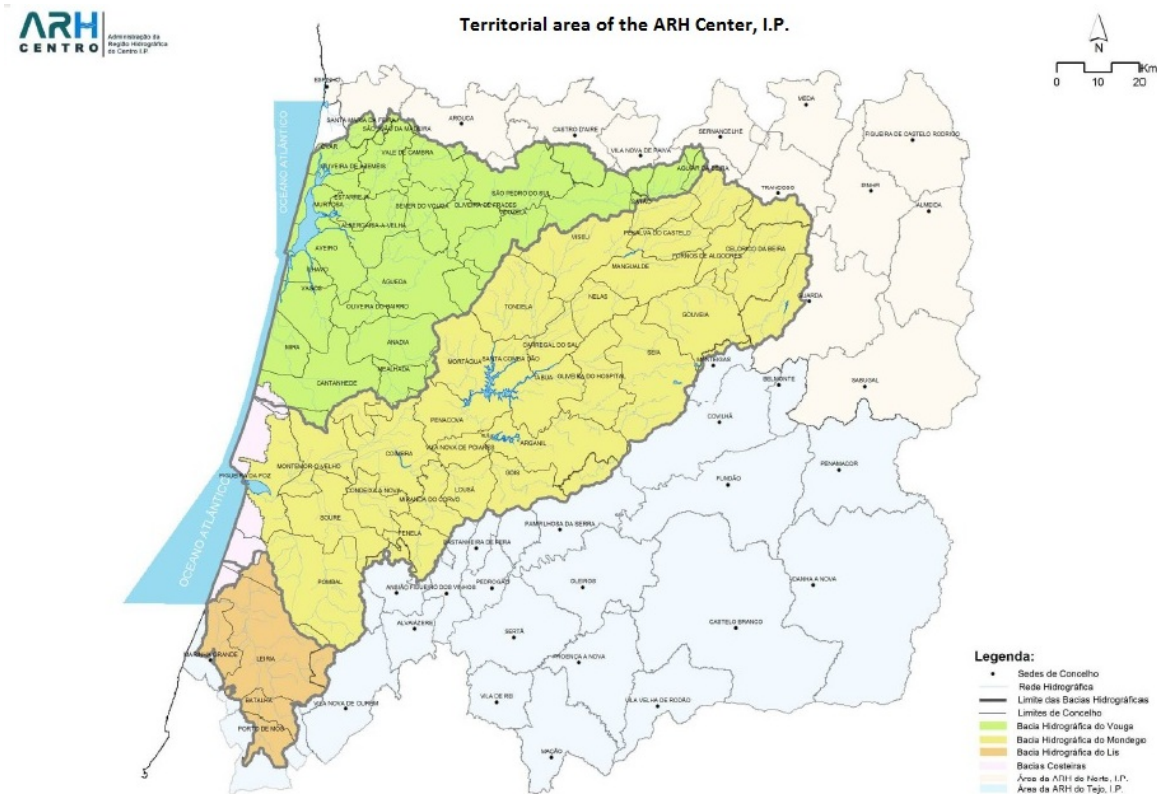


Figure 3.12. Spatial Area of the ARH Centro, I.P. (Source: www.arhcentro.pt)

The ARH Centro, I.P. still fits in the position of a modern public administration creating innovative conditions for a better proximity between the administration and the administered throughout mechanisms that allow a better participation of the users and the society in the management of the water resources. Among these mechanisms, it is distinguished the Council of the Hydrographic Region, advisory body of the ARH Centro, I.P. where the main users of the water, associations and entities of the local administration are represented, at regional and central level.

The vision of the entity is of *'being a reference, efficient and innovative organization, committed to putting into practice the sustainable management of water resources per*

river basin, fostering a culture of co-responsibility of the users and the society in general'.¹⁴

The administration is guided by a set of values that qualify and enhance the service to the exterior as well as the internal work environment. The values that are given priority to at this level are:

- Common identity and team spirit;
- Motivation, communication and creativity;
- Respect, ethics and responsibility;
- Sense of public service and partnership with the society.

The strategic objectives aimed by the Administration of the Hydrographic Region of the Center, I.P. are:

- Strengthening the protection and enhancement of water resources;
- Increasing the number of measures for the protection, recovery and adjustment of the hydrographic network and the coastline, and risk mitigation;
- Enhancing the production and use of knowledge about water resources and coastal and estuarine watershed;
- Promoting the awareness of the society about the environmental and economic intrinsic value of water and the accountability for its efficient use; and creating a framework of institutional relationships encouraging partnerships that would allow the reconciliation of divergent interests as well as value creation;
- Implementing an effective and efficient organization, having as a principle the continuous improvement of services management and the adoption of the best environmentally friendly practices.

The paradigm that governs the management of water resources sets out from the perception of water as an economic, environmental and social good, arising from its useful and scarce character. Considering the river basin as the management unit and

¹⁴ Activities Plan, 2011, The Administration of the Hydrographic Region of the Center, I.P., The Ministry of Environment, Territorial Planning and Regional Development

looking for conciliation between interests and objectives regarding the partnership with water users, it is agreed that the planning of the water resources must be considered a potential strategic tool of the competence exercise of the Administrations of Hydrographic Regions. According to nº 2 of the 3rd article of the Decree nº 208/2007 of the 29th of May, the ARH have the following tasks:

- Developing and implementing Management Plans for River Basins and Specific Plans for Water Management and defining and implementing measurement programs;
- Establishing the hydrographic region's network for monitoring water quality, as well as developing and implementing its respective monitoring program;
- Deciding on the issue of water resources use titles and monitoring the compliance of its implementation;
- Analyzing the characteristics of the hydrographic region and the impacts of human activities on the water status, together with the economic dimensions of the water uses;
- Preparing the register of protected areas and identifying the catchment areas for water for human consumption;
- Promoting the regeneration of water resources and river systematization, as well as coastal protection;
- Applying the appropriate economic and financial system in the river basins, collecting the taxes of catchment areas, and applying the part that fits in the water management of river basins.

The direct beneficiaries of the services offered by the ARH Centro, I.P. are the municipalities covered by the River Basins of the Hydrographic Region, public administration at central and regional level, private entities, non-governmental organizations, individuals, regional and local development associations and agencies, and other private and non-profit entities.

The Department of Planning, Information and Communication is responsible for coordination of the planning of water resources and the monitoring and knowledge

development systems, as well as the information and communication systems, including public participation in the management of water resources, through the following:

- River Basin Plans;
- Hydrographic Region Management Plans;
- Reservoirs and public waters development plans;
- Coastal zone development plans;
- Estuaries development plans;
- Specific water management plans;
- Accompaniment of instruments for spatial management;
- Protected and catchment areas for drinking water;
- Monitoring and Laboratory;
- Atlas of water resources;
- Public participation initiatives;
- Environmental education and awareness for sustainable water use;
- GISs.

The River Basin Plans define guidelines for water recovery, protection and balanced management, on a spatial approach, for a river basin or an aggregation of small watersheds in accordance with the Decree Law nº 45/94 of the 22nd of February, repealed by the Law nº 58/2005 of the 29th of December (Water Law - WL). The Water Law, approved by the Law nº 58/2005 of the 29th of December, transposes into internal legal order the Directive nº 2000/60/EC of the European Parliament and Council, of the 23rd of October, establishing a framework for community action in the field of water policy and aiming to establish a framework for the protection of inland surface waters, transition waters, coastal waters and groundwater. Thereafter, the referenced directive sets 2015 as the deadline for the member states in achieving the environmental objectives set by the WFD/WL, through the implementation of the programme of measures specified in the Management Plans of the Hydrographic Region Management Plans (PBRH). The PBRH are water planning instruments that aim to represent themselves a support base for the management, protection and environmental, social and economic enhancement of the

waters. Thus, the ARH Centro, I.P. is promoting the development of the River Basin Management Plans of the Vouga, Mondego and Lis Rivers, integrated in the Hydrographic Region Nº 4.

Estuaries development plans aim to protect their waters, river beds and banks and the dwelling ecosystems, as well as the environmental, social, economic and cultural enhancement of the coastal borders and of all the area of the intervention plan.

The Monitoring and Laboratory Division intends to ensure the awareness of the condition of water and groundwater bodies, guaranteeing the management of the monitoring networks in the area of jurisdiction of the ARH Centro, I.P., joint with the National Water Authority.

Following the extinction of the Autonomous Committee of the Port of Aveiro and the creation of the Administration of the Port of Aveiro, S.A. (APA) (Decree nº 339/98 of the 3rd of November), whose jurisdiction area became restricted, the institutional responsibility for managing the Ria de Aveiro was amended, staying in 2002 under the control of the Ministry of Environment, Territorial Planning and Regional Development (Decree nº 40/2002 of the 28th of February). Ever since, there have been several attempts to promote other institutional frameworks for an integrated management of the Ria de Aveiro¹⁵:

- One was based on the creation of the Department of the Ria de Aveiro (DRIA) in 2001, included in the Regional Directorate of Environment and Territorial Planning of the Center (DRAOT Centro), but which never carried its duties;
- Another one was the trial of an agreement between DRAOT Centro and APA, regarding the management of the areas of the Ria transferred to RDETP and the training of technicians from the first, but which was later declared void;
- Yet another one had to deal with the attempt of creating, in 2005, an Office for Integrated Management of the Ria de Aveiro, through a Regulatory Decree that hasn't been adopted however;

¹⁵ Report of the activities developed in the ambit of the Ria of Aveiro, 2009, The Administration of the Hydrographic Region of the Center, I.P., The Ministry of Environment, Territorial Planning and Regional Development

- Between 2006 and 2008 the management of the Ria de Aveiro was attributed to the Commission for the Coordination and Regional Development of the Center (CCDRC), following the integration of DRAOT in its services. In the absence of an effective transition, not just of licensing procedures for the use of the public hydric domain, but also, and mainly, of technical and financial resources, the promoted management measures were limited.

With the creation of the Administration of the Hydrographic Region of the Center, I.P., starting the 1st of October 2008, the management of public hydric domain of the Ria de Aveiro remained the responsibility of this new institute diverted from the Ministry of Environment, Territorial Planning and Regional Development. The ARH results from an institutional model for the management of water resources falling within the scope of the Water Law (Law 58/2005 of 29th of December) allowing for the first time, a set of key conditions for the setting out a management model for the water resources, in an innovative way, adapted to the characteristics of the Ria de Aveiro. On one hand, the

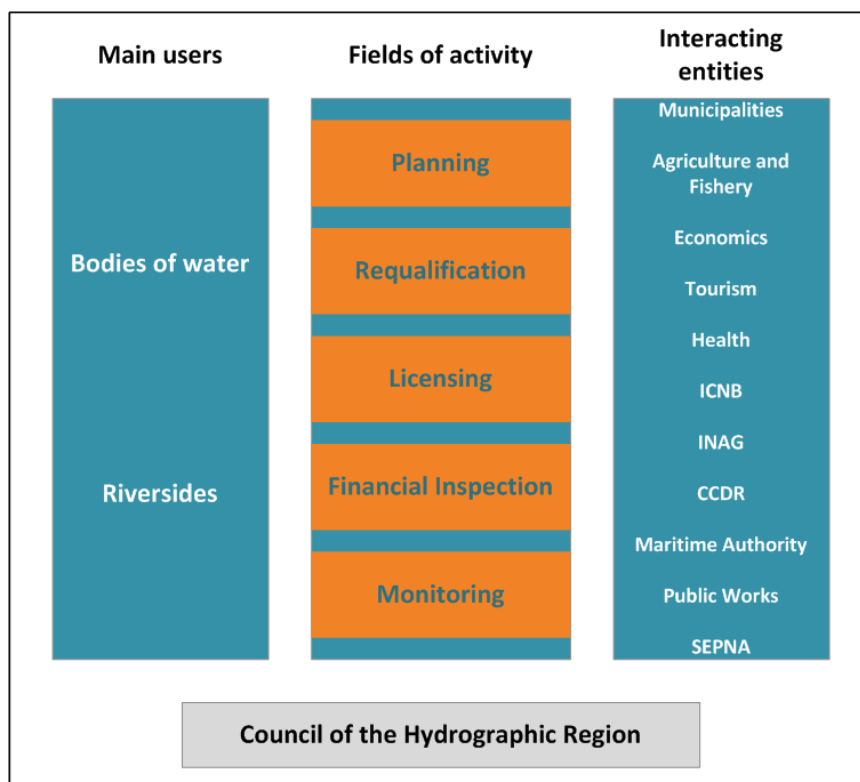


Figure 3.13. The Ria de Aveiro management in the ambit of ARH Centro, I.P. (Adapted from the Report of the activities developed in the ambit of the Ria de Aveiro, 2009)

legislative framework created specific organisms, totally dedicated to the integrated water management of inland and coastal water resources, the Administrations of Hydrographic Regions (ARH), which became particularly important in framing the management model of the Ria de Aveiro.

Moreover, this new legislative framework creates innovative conditions for a better proximity between the Administrations and administered through mechanisms that allow a greater participation of the users and the society in the management of water resources. Such a mechanism lies in the council of the hydrographic region, which brings together a diverse set of entities at a central level but also regional representatives, accompanying and scrutinizing the activities developed by the Administration of the Hydrographic Region.

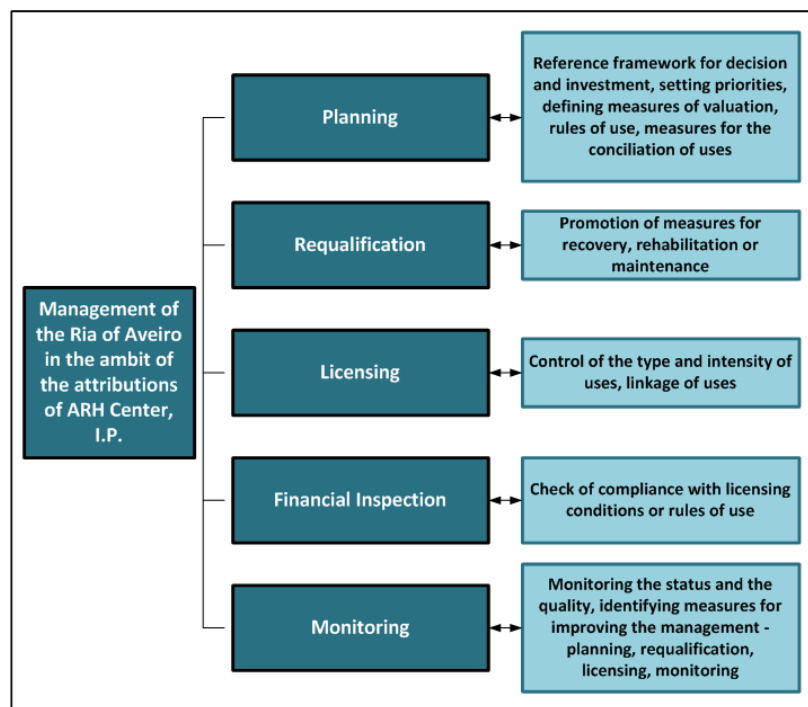


Figure 3.14. Fields of action of the ARH Centro, I.P. in the Ria of Aveiro (Adapted from the Report on the activities developed in the ambit of the Ria of Aveiro, 2009)

Another mechanism is based on the possibility of delegating the management competences of water resources to user associations of the public hydric domain, whose legal system was established by the Decree nº 348/2007 of the 19th of October 2007, or even to municipalities, according to the Article nº 9 of the Law nº 58/2005 of the 29th of December, or to municipalities associations, according to the Article nº 13 of the Decree nº 226-A/2007, of the 31st of May.

Also in the context of the Water Law and its interface with land management it is important to increase the reference to the future Development Plan of the Estuary, regulated by the Decree nº 129/2008 of the 21st of July, which establish the broad guidelines for the integrated management of the water bodies and estuarine resources, as well as the related banks.

The management of the Ria de Aveiro requires particular attention from the ARH Centro, I.P., due to the following factors:

- The negative effects of the pressure of economic growth upon water resources, and the related natural, environmental, socioeconomic and landscape values;
- The multiple uses of water resources and their implications for the maintenance of quality and stability of the Ria de Aveiro;
- The covered extent;
- The interface environment in which it can be found, as a consequence of its coastal and estuarine surroundings, as well as the integration in the basin of the Vouga River;
- The complex institutional context that, in addition to the organisms from different sectors of activity of the central government, is covered by 11 municipalities;
- The lack of structural interventions for the enhancement and control of the different uses in a major part of the hydric domain in the area.

The Ria de Aveiro also includes the list of Natura 2000 sites, being awarded therefore a European and national importance, fact that implies an increased responsibility from the

Portuguese state in adopting a quick and effective solution for the management of the Ria de Aveiro, in the light of modern principles of environmental governance and management of water resources. Despite the fact that the problems of the Ria involve a broader extent, it is particularly appropriate to focus its management model according to the Water Law (Law nº 58/2005 of the 29th of December).

In light of the current institutional and legislative framework of the main requisites for the management of the Ria de Aveiro, brought under control by the ARH Centro, I.P., the following stand out:

- Preparing and adopting the Vouga Estuary Development Plan (the Ria de Aveiro) to guide and regulate the preferred uses and identify new opportunities of use according to the carrying capacity;
- Joint of uses and licensing and control of uses (multiple and often conflictual with each other);
- Joint between different entities responsible for the Ria;
- Maintaining navigable canals, public berths, dams and waterfronts in the Public Maritime Domain (PMD) and small hydraulic infrastructures;
- Controlling water quality and infesting species;
- Provisioning databases and GISs that systematize jurisdictions, uses and titles, etc.;
- Collaborating mechanisms that involve users and public administration;
- Measures of mitigation and adaptation to climate variability and change, and risks;
- Adequate human resources.

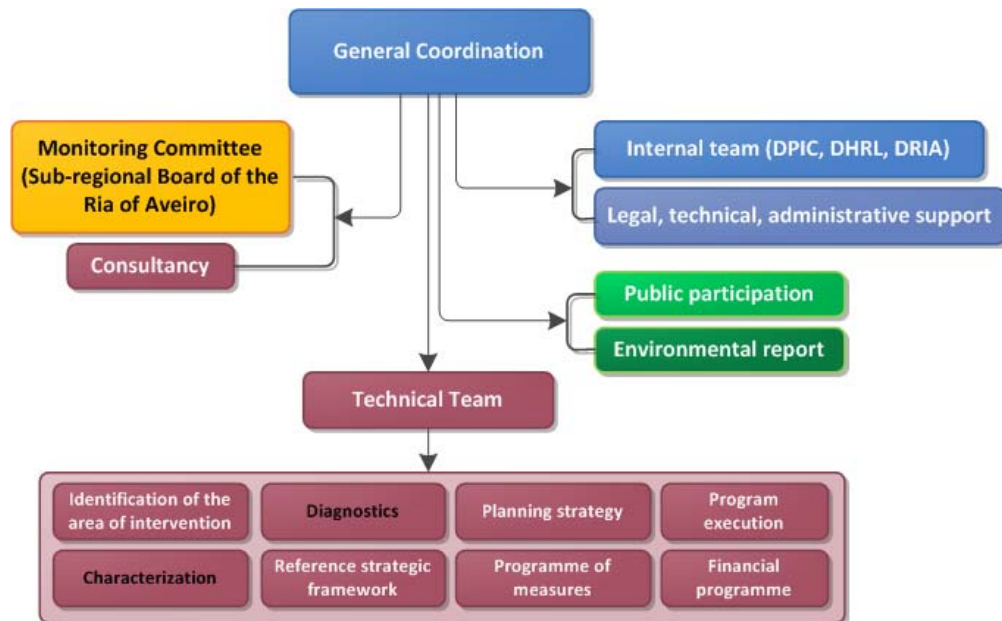


Figure 3.15. Preview of the organizational model of the elaboration process of the Vouga Estuary Development Plan
(Adapted from the Estuaries Development Plan)

The management of the Ria de Aveiro, primarily concerning the PMD associated with its banks, berth and bodies of water, have consisted since the creation of the ARH Centro, I.P., a core of particular attention. The fact was later emphasized among the operational objectives of the ARH Centro, when including *‘the promotion of the integrated management of the main water bodies, giving priority to the Ria de Aveiro’*.

The figure 3.16. shows the territorial scope of the ARH Centro, I.P. jurisdiction, according to the concept of littoral, coastal area and coastline.

Starting the 90’s, the European Commission stated the need of an integrated management of the coastal zone, as a result of the existing lack of coordination between stakeholders (Government and other sectors). The estuary and coastal area of the Ria de Aveiro were, therefore, perfectly adapted to the previous statement. It was at that moment, that the Aveiro lagoon became the target of several research projects as well as some action programmes and the scientific community started giving special attention to the Ria de Aveiro, that is the planning and management of the lagoon area.

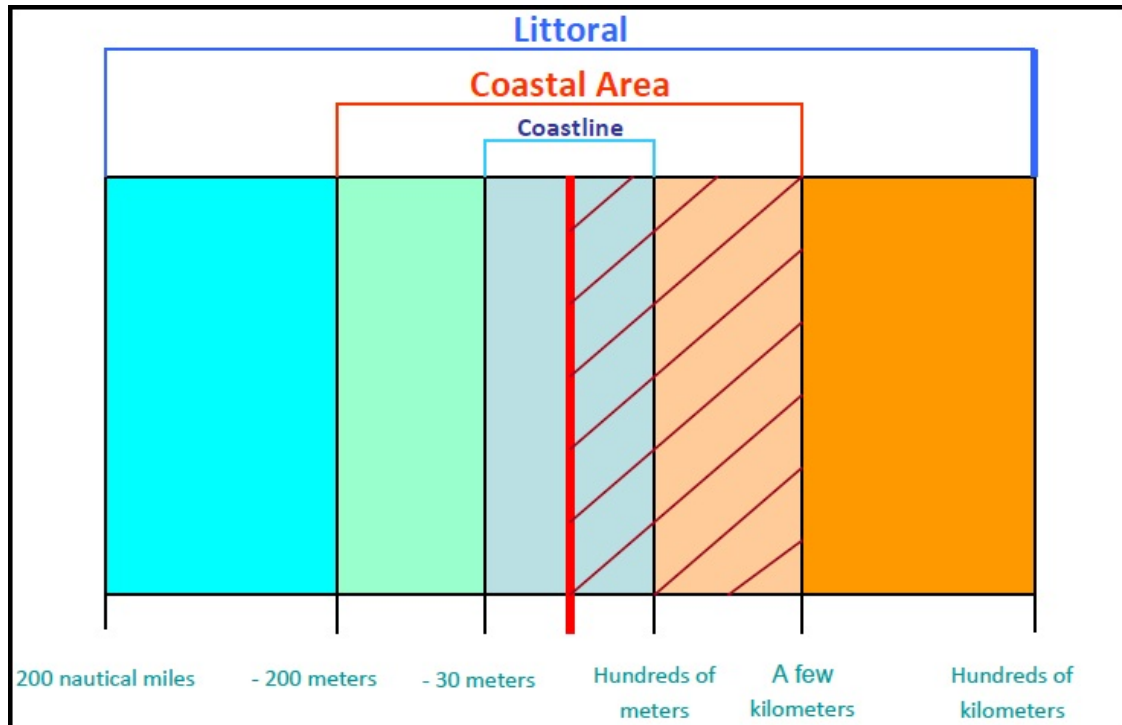


Figure 3.16. - Coastal area, the concept

In this respect, in 1996, a first research project was brought forth, the Programme on Integrated Management for the Ria de Aveiro – MARIA (LIFE'96 ENV/P/000601), closely following the main principles of ICZM. The project was established by the University of Aveiro in partnership with the local, regional and central government and different local associations, and it was funded by the EU Programme LIFE'96. Its goal was of finding the right tools for a management framework orientated for an integrated development and a better participation of the stakeholders, as well as a conciliation of interests for the Aveiro coastal lagoon and other similar areas (Alves *et al.*, 2000b)

Based on eight basic principles, the process of Integrated Coastal Zone Management (ICZM) means to ensure a good coastal zone management, by using the good practices identified through the European Commission's demonstration programme (Table 3.1.).

In the Portuguese context, the Government's improvement is noted in the legislation applied to the coastal zones, for a better development of a robust legal base in matters of governance (institutional and competences) (MAOTDR, 2009). The National Strategy of Sustainable Development shows the introduction of the objectives of the European Recommendations regarding the Integrated Coastal Zone Management, in the national

sectorial policies (APA, 2006; CEC, 2000). Also, lately, there has been an increase in the financial resources, made available for actions of coastal defense and of environmental protection. Therefore, the coastal zones assumed a considerable importance in local and national strategies, hence the strong and complex threats they encountered in the last years. (Alves and Ferreira, 2006)

Approved in 2009, the Portuguese National Strategy for Integrated Coastal Zone Management (NSICZM) identifies a series of main principles: Sustainability and Intergenerational Solidarity; Cohesion and Equity; Prevention and Precaution; Systemic

Table 3.1. Methodological approach of the MARIA (LIFE'96) Programme	
1st Phase	The Ria dynamics knowledge will help the definition of guidelines for the intervention actions;
2nd Phase	Study and diagnosis of the Ria (potentialities/problems/vocations), its navigability, the interest of the navigation activities and the municipalities interventions;
3rd Phase	Elaboration of theoretical models to the revitalization of the quays;
4th Phase	Evaluation of the various quays and selection by multi-criteria analysis of those who will be object of intervention;
5th Phase	The model of revitalization will be applied to the target quays;
6th Phase	Elaboration of the conclusions and recommendations about the developed theory and practice;
7th Phase	The most appropriate models of revitalization to each quay will be applied.

Source: Alves *et al.*, 2000a

Approaches; Technical and Scientific Knowledge; Subsidiarity; Participation; Co-responsibility; and Operability (MAOTDR, 2009). For the Aveiro lagoon, there have also been particularly developed several research projects and spatial planning interventions, in the previous years, as a consequence of the risen interest and need for an integrated management strategy.

Table 3.2. ICZM Principles, as stated by the European Commission	
(a)	A broad overall perspective (thematic and geographic) which will take into account the interdependence and disparity of natural systems and human activities with an impact on coastal areas;
(b)	A long-term perspective which will take into account the precautionary principle and the needs of present and future generations;
(c)	Adaptive management during a gradual process which will facilitate adjustment as problems and knowledge develop. This implies the need for a sound scientific basis concerning the evolution of the coastal zone;
(d)	Local specificity and the great diversity of European coastal zones, which will make it possible to respond to their practical needs with specific solutions and flexible measures;
(e)	Working with natural processes and respecting the carrying capacity of ecosystems, which will make human activities more environmentally friendly, socially responsible and economically sound in the long run;
(f)	Involving all the parties concerned (economic and social partners, the organizations representing coastal zone residents, non-governmental organizations and the business sector) in the management process, for example by means of agreements and based on shared responsibility;
(g)	Support and involvement of relevant administrative bodies at national, regional and local level between which appropriate links should be established or maintained with the aim of improved coordination of the various existing policies. Partnership with and between regional and local authorities should apply when appropriate;
(h)	Use of a combination of instruments designed to facilitate coherence between sectorial policy objectives and coherence between planning and management.

Source: Council Recommendation of the European Parliament and of the Council of the 30th of May 2002, concerning the implementation of the Integrated Coastal Zone Management in Europe (2002/413/EC)

Later, in 1999 (started in 1998), the next European project coming after was the ESGIRA-MARiA (LIFE'99 ENV/P/000673), following up the efficiency of the main principles of ICZM. Co-financed by the European Union, the project aimed to continue the work developed during the MARIA Project and to identify, at the same time, the weaknesses in the general disjointed nature of actions taken by the administration, at different levels, the inadequacy of legislation and implementation instruments, as well as in the lack of coordination between the groups/sectors involved in the use of the coastal lagoon area (Alves *et al.*, 2000b; Alves *et al.*, 2001a).

Another attempt was made in 2008, by the municipalities surrounding the Aveiro Lagoon, through UNIR@RIA, and inter-municipal spatial plan, designed and approved for this particular area. Though the plan was only drawn in early 2000, the project was only concluded in 2008. The plan aims to establish integrated guidelines for the surrounding territory of the Aveiro lagoon and its natural extension through the drainage basin of the Vouga and Cértima River.

The programme that targeted the Ria de Aveiro at the moment is the POLIS LITORAL Ria de Aveiro, which manages the intervention strategies for the recovery and valorization of the coastal lagoon (PARQUEXPO, 2008). One of the main differences between this programme and the previous plans was that the POLIS started where the UNIR@RIA began to have a lack of municipal financial support. As a part of the four national POLIS LITORAL programmes, whose target are problematic, troubled pressured areas, the project itself have special funding mechanisms.

Relationships between the stakeholders involved in the Ria de Aveiro's management reached a better communication level through the MARIA research project, showing the benefits of an integrated management approach. Due to the lagoon's social, economic and cultural dynamics, the improved management led to a better development of the following project, the ESGIRA-MARiA, when relations were taken to a different level. It was through the execution of the pilot projects, that the ICZM strategy clearly proved its help in the lagoon management, and the communication bonds strengthened between stakeholders.

The new approach towards the lagoon's management was accomplishable through the use of the two research projects, regarding the ICZM policies and principles, thus creating a clear coordination and conciliation between the large number of stakeholders involved in the lagoon's management and its users. This fact led to the elaboration of the UNIR@RIA plan, clearly different from the previous ones. The stakeholders had the necessary mechanisms in order to reach the population for a participatory planning process, leading to a better management strategy and better intervention proposals.

However, the action plan that rose upon all others, was the POLIS LITORAL Ria de Aveiro, particularly because of the economic opportunity it represents. The plan also achieved some of the previously proposed actions from the UNIR@RIA plan. Research studies used existing knowledge in the field and were realized by multidisciplinary teams, taking advantage of the currently existing philosophy of dialog and coordination between different stakeholders. The success of the plan lies in the fast transition from the studies towards the projects themselves, due to the following facts:

- The economical effort to ensure that each project had a pre-set budget;
- The financial condition to execute them was already accounted for.

Table 3.3. ICZM Principles present in the subject of analysis

ICZM Principles	MARIA	ESGIRA-MARiA	UNIR@RIA	POLIS LITORAL Ria de Aveiro
A broad "holistic" perspective	√	√	-	√
A long term perspective	-	√	√	√
Adaptive management during a gradual process	√	√	-	-
Reflect local specificity	√	√	√	√
Work with natural processes	-	√	-	√
Participatory planning	-	√	√	-
Support and involvement of all relevant Administrative bodies	√	√	√	√
Use of a combination of instruments	-	√	√	√

Source: Alves *et al.*, 2011

The complexity and time consuming features of the ICZM principles implementation are emphasized by analyzing the latter projects, plans and programmes (see Table 3.4). After more than ten years from the first attempts of coordination, conciliation and integrated management in the spatial planning acts, the Ria de Aveiro Lagoon is finally covered by all ICZM principles. Also, another fact that comes forth is the importance of the financial aspects for the execution of the management strategies and plans (Alves *et al.*, 2011).

Table 3.4. Projects, plans and programmes assessment and comparison

Main Goals	Key-agents	Methodology	Results
<p>MARIA Project</p> <ul style="list-style-type: none"> - Building the capacity of several different entities to work together; - Taking profit from the investments and interventions done in the lagoon in defining cooperation approaches to ensure a sustainable use of the area. 	<ul style="list-style-type: none"> - Agents from the regional to local governments, with legal competencies to intervene on the lagoon; - The Industrial District Association; - The Agricultural and Rural Development Institute; - The Institute for Nature Conservation and Biodiversity; - Local non-governmental associations; - The University of Aveiro, as a research and development institution but also as a 'neutral' partner, leading the partnership. 	<ul style="list-style-type: none"> - 1st stage: identifying and synthesising the existing information to assess the present situation frame; - 2nd stage: analysis and evaluation of the existing projects, plans and programmes assessing the interference level in the natural ecosystems, their contribution to the environment degradation and mitigation measures foreseen in them (this stage allowed the identification of the concerted actions or their lack, as a hint in the elaboration of recommendations, as well as the improvement of the information trade between the agents); - 3rd stage: partners' intention to contribute to a definition of integrated management structure for the Aveiro coastal lagoon (testing the ability to manage the multiplicity of environmental vectors of the lagoon region); - Priority areas: the traditional fishery activities, the salt production, the agricultural practices and the landscape protection. 	<ul style="list-style-type: none"> - Creating the routine of cooperation and conciliation between the different stakeholders involved in the Aveiro lagoon management; - Creating a definition of an integrated management structure for the sustainable development of the area; - Creating routines of dialog where there were none; - Sharing the experience and findings as a European Demonstration Programme; - Defining the four priority areas that served as a basis for the ESGIRA-MARIA Project.

ESGIRA-Maria Project			
<ul style="list-style-type: none"> - Taking advantage of the previously opened paths of cooperation between the different stakeholders allowing a better implementation of the pilot projects that came out of the MARIA Project; - Testing the efficiency of an Integrated Management Structure through negotiation among the various interests groups (a wide-ranging partnership was created within the framework of the 1996 LIFE project - MARIA); - Contributing to the identification of integrated management methodologies for coastal areas; - Identifying mechanisms that allow the (re) shaping of a structure of this typology. 	<ul style="list-style-type: none"> - The core group of the project, led by the University of Aveiro; - Local and regional government; - Regional associations; - Industrial, environment, tourism and non-governmental entities. * Multidisciplinary view over the lagoon and its management issues. 	<p>The method used was based on the creation of four different pilot projects:</p> <ul style="list-style-type: none"> - Rehabilitation and valorisation of the existing piers along the lagoon channels; - Rehabilitation of the salt marines (salt pans); - Management of the Lower Vouga agricultural field, allowing the co-existence of the agricultural activities with the existing natural habitats; - Implementation of measures that promote the classification and the integrated management of the protected landscape area of the Cáster river mouth. - Developing wide enough actions that integrated all the physic geographic area of the lagoon area that had already been subject of a previous investigation and drawing an example of the daily management issues of the lagoon. - Explaining the projects to the involved stakeholders and the population by having specific formation sessions, various workshops, the inclusion of the project on the University Open Week and scientific exhibits in the municipalities (Alves <i>et al.</i>, 2000a; Alves <i>et al.</i>, 2000b; Alves <i>et al.</i>, 2001b). 	<ul style="list-style-type: none"> - Strengthening routines of the cooperation between the different stakeholders and conciliation of interests; - Dividing the developed work in specific groups inherent to each pilot project, promoting a larger interaction which allowed a greater capacity of knowledge transfer that was reflected on the quality of the final product of each pilot project; - Transferring the work done in each project to the local population which enhanced the identity feeling like allowing a greater sense of awareness to the lagoons issues and the solutions proposed and in execution; - Raising attention to the lagoon and to the need of an integrated management; - The output of a number of publications in journals, conferences and books that allowed the dissemination of the findings to go even further.

<p>- Achieving the sustainable development and qualification of the Aveiro Lagoon and surrounding territory;</p> <p>- Setting a pair of fundamental strategic vectors, the lagoon as a privileged natural space and the lagoon as an integrated, cohesive and dynamic socio-economic space.</p>	<p>- Local, regional and national government;</p> <p>- Existing plans for the lagoon (AMRia/CPU, 2006; Sousa <i>et al.</i>, 2010).</p>	<p>- Making a series of characterization studies, in order to access the lagoons spatial reality (complemented with the existing studies and municipal projects);</p> <p>- Taking into consideration the high hierarchical plans such as the regional spatial plan and the coastal zone management plan to achieve the necessary conciliation and articulation between all the existing plans;</p> <p>- Setting measures to rehabilitate degraded and abandoned areas ensuring that the natural values would be considered as a priority instead of other uses and functions (environmental information and education of the surrounding population);</p> <p>- Allowing the development of sustainable policies based on the best environmental practices and supporting the maintenance of production systems, in order to reach the vision of an integrated, cohesive and dynamic socio-economic space;</p> <p>- Promoting the traditional activities compatible with nature conservation creating equilibrium conditions between production and natural values;</p> <p>- Improve the accessibility of the area taking advantage of its position and complementing the existing roads networks (allowing an easier accessibility both to the local and outside population (AMRia/CPU, 2006)).</p>	<p>- Threatened by the current lack of funding;</p> <p>- Putting a series of actions on standby.</p>
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<p>POLIS LITORAL Ria de Aveiro</p>	<p>The programme is based in three main objectives:</p> <ul style="list-style-type: none"> - An environmental preserved lagoon: coastal and lagoon defence and protection minimizing risks; - valorisation and protection of the natural patrimony and landscape; - Economic dynamic lagoon: valorisation of the economic resources as a social and economic competitive factor; - Lagoon of multiple existences: promotion and dynamisation of the lagoon. 	<ul style="list-style-type: none"> - The Portuguese government; - A legal society that co-manages the programme; - The regional government; - Multidisciplinary research teams; - Stakeholders and users of the lagoon. 	<ul style="list-style-type: none"> - The Programme originated four vectors of work and twenty nine sub vectors; - Funding for each vector already accounted for; - Limiting and distributing the amount of funding, counting with approximately 96 million € (59% European funds and 41% National funds); - The studies to begin with the certainty that the propose actions would actually be implemented and carried out; - The Portuguese government created a legal society to co-manage the programme along with the regional; - Carrying the studies by multidisciplinary teams involving a large number of stakeholders and users of the lagoon (PARQUEXPO, 2008). 	<ul style="list-style-type: none"> - Some of the proposed studies have already been approved and at least seven projects are being implemented and built at the moment.
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Adapted from Alves *et al.*, 2011

3.3. Ecosystem valuation applied to the study area

3.3.1. Methodology

Regarding the methodologies to adopt in a study of economic valuation of ecosystems, there is a significant level of agreement between various authors on the main steps to follow in order to find an estimate value of ecosystems, that would be sufficiently robust and effective (Chee, 2004; TEEB, 2008).

There are at least three types of approaches that set out. It is thus necessary to choose an appropriate evaluation methodology, meant either for impact assessment, partial valuation of ecosystems or their total valuation. The analysis method for impact assessment complies for a study whose aim is to examine the effects of a specific external factor, on an ecosystem. In the case of trying to identify a specific ecosystem, the appropriate method should consist of a partial valuation. In the case of the study covering an area with several ecosystems, which has as a primary objective the definition of a strategy for development or conservation, the approach corresponds to a total valuation.

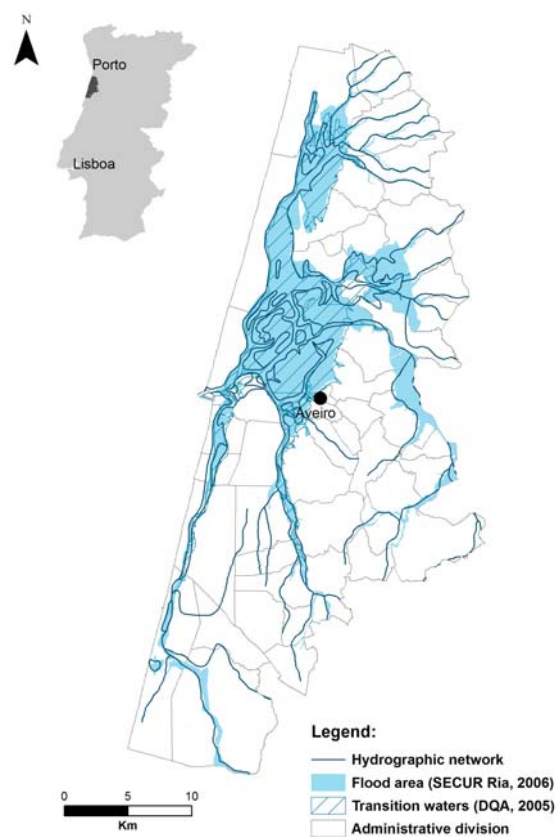


Figure 3.17. The Ria of Aveiro Lagoon study area
Source: Silva *et al.*, 2011

After choosing the proper valuation method, it follows a second phase consisting of several steps:

- i) Definition of the area, its borders and its surrounding areas;

ii) Identification and ranking of the components, functions and attributes of the present ecosystems;

iii) Identification of the uses of ecosystems in order to obtain the necessary information for their monetary valuation.

The process is then completed with an assessment of the economic potential and the implementation of the most appropriate method of estimation (Barbier *et al.*, 1997).

The present study case, considering it as a first approach of the kind in the area, as well as its potential integration in a future scenario where the probability of flood events occurrence may be more frequent, uses the method of total valuation of the ecosystems present in the study area - the Ria de Aveiro and its surrounding areas. The work began with the spatial delimitation of the study area.

It was therefore assumed the area defined by the Water Framework Directive (WFD), with transitional waters for the area of the Ria de Aveiro, information from the study carried out within the SECUR-Ria, by the Association of Municipalities of the Ria (DEP/UA, 2006) regarding the area of maximum flood between 1857 and 2005, and information from the Official Administrative Map of Portugal 2010 (OAMP, 2010). The process led to an analysis territory that covers an area of 184.5 km², containing parts of areas of 47 villages belonging to nine different counties.

The project Secur-Ria - Security in the Region of Aveiro, aimed to endow the 11 municipalities and the Association of Municipalities of the Ria (AMRia) with risk and safety plans. There were geo-referenced the areas and situations of risk, as well as the resources' location and the security and emergency-response systems. The plans and the security and emergency charters are available online, ensuring the access of the coordinating entities of the Civil Protection through the specific terminal equipment.

The used maps and land cover belong to maps database CORINE Land Cover (CLC), implemented with the aim of developing an information system on the condition of the environment at a European level (Caetano *et al.*, 2005). It includes accurate and comprehensive information on the occupation/land uses in the years 1990, 2000 and

2006, for the national territory. Regarding the technical specifications, it should be noted that these geographical data sets are at 1:100,000 scale, respecting the Minimum Mapping Unit (MMU) of 25ha, and a line spacing of 100 m. It also important to point out that related to the MPU used, there are some technical reserves in the analysis of the results, because the changes in isolated areas with areas below the UMC are not mapped (Painho and Caetano, 2006). This condition may be particularly relevant in the study area (the Ria de Aveiro).

The nomenclature used, explained by Bossard *et al.* (2000), was designed in order to be useful in the land planning and organization and is divided into three hierarchical detail levels. Adopting the method used by Pinto (2008) in the definition study of a support system in the management of coastal zones, in the pass Ovar-Mira that explains, after Caetano *et al.* (2001), that the passage from a more detailed level to a less detailed one is achieved through the generalization by categorization, which promotes the elimination of the detail by the aggregation of more general categories. Level 1 provides the least details, describing five mega-classes of occupation / land use, followed by the second level, of intermediate detail that takes up fifteen classes and, finally, level 3, which introduces 44 types of land use. The present study didn't use the level 3.

The system of coordinates used in defining the pattern of land use types differs with the period. So, there is the system Lisboa Hayford Gauss IGEOE for the years 1990, 2000 and the system of coordinates European Terrestrial Reference System 1989 Portugal Tranverse Mercator 2006 (ETRS 1989 Portugal TM06). This difference in the system of coordinates implied the need to transform it, in order to obtain uniformity.

Consecutively, the three time periods were compared, using the GIS, in order to identify changes in land use, to recognize what type of occupation succeeded the previous one.

The GIS technology is an integrated collection of computer software used for managing information about geographic places, analyzing spatial relationships, and model spatial processes. They also provide a framework for gathering and organizing spatial data and related information, for display and analysis.

The referred software provides tools for data analysis, displaying the results in the shape of powerful, interactive maps that reveal how things join and work together, for a better and more informed decision-making.

In addition to the real changes that occurred with the use of soil, was yet considered a possible future scenario due to climate change, where a considerable change in the study area was supposed, particularly of the areas adjacent to the Ria. Regarding the land use changes, it was assumed that the area previously referred to as the transitional waters would become the permanent water plan and the difference in size between this polygon and the flood polygon mentioned above would be a subject area.

Afterwards, a bibliographic research was realized, with the incidence in studies on the topic of natural ecosystems, their functions and economic value in order to establish correlations between the types of land use and types of ecosystems present in the area, thus enabling to identify the changes of ecosystems and their inherent value along the study period.

3.3.2. Analysis of the land use patterns

The figure 3.18. shows the percentage of territory occupied by different land uses according to the first level of the CLC, for the years 1990, 2000 and 2006, respectively.

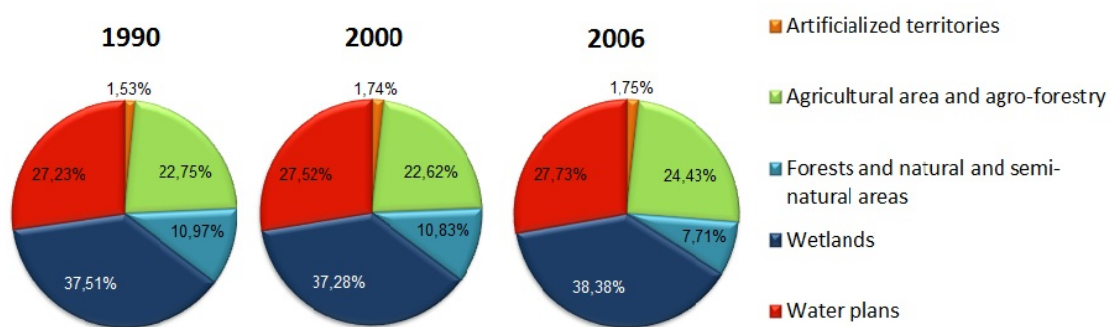


Figure 3.18. Distribution of land use classes for the years 1990, 2000 and 2006
(Source: Silva *et al.*, 2011)

The data analysis shows a continuous growth of the artificialized territories, water plans and wetlands. On the other hand there is a decrease in forest areas and natural and semi-natural areas, as well as in agricultural areas and agro-forestry.

Once identified the trends of change in land use on a higher level within the CLC, it is now important to identify which were the transfers of uses, namely, which typology succeeded the former one, quantifying and spatializing them.

3.3.3. Land use transfer

In the Figure 3.19. can be observed the transfers of land use disaggregated at the second hierarchic level of the CLC: Urban Fabric (UF), Industry, Commercial and Transport Units (ICTU); Mine, Dump and Construction Sites (MDCS); Arable Land (AL); Pastures (P), Heterogeneous Agricultural Areas (HAA), Forests (F), Scrub and/or Herbaceous Vegetation Associations (SHVA), and Open Spaces with Little or No Vegetation (OSLNV); Inland Wetlands (IWL), Maritime Wetlands (MWL), Inland Waters (IW) and Marine Waters (MW).

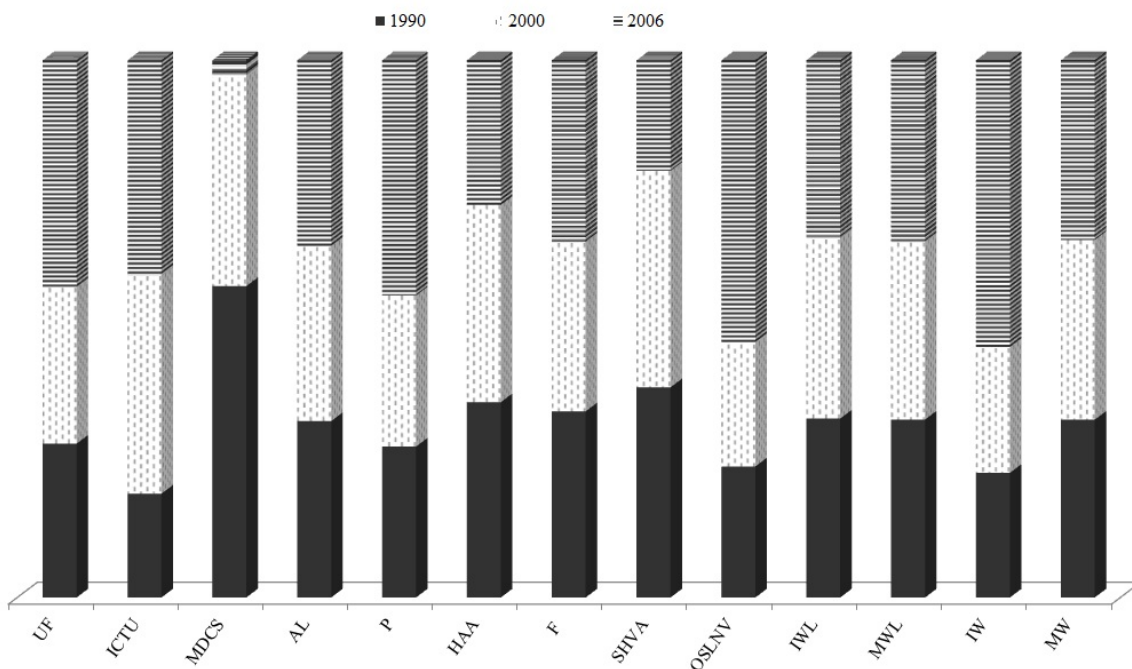


Figure 3.19. Transfers of land use disaggregated at the second hierarchic level of the CLC
(Source: Silva *et al.*, 2011)

Using the GIS software, there were represented the land uses of the three periods under review and their adjustments amendments from 1990 to 2000 and from 2000 to 2006. Taking into account the reduced amounts previously recorded, in relation to the percentage of modified territory over the three periods, there is only shown a zoom of an illustrative area where these changes have occurred. In the figure 3.20. it can be observed the change occurred in the area surrounding the Aveiro Port, the presented maps portraying the land use in 1990, the changes elapsed from 1990 to 2000 and the changes from 2000 to 2006.

Analyzing the areas and the changes in the land use, and comparing the two periods, one can verify that the number of exchanges between the types of land use in the period 1990 to 2000 was higher than in the period 2000 to 2006.

However, the total extent of changes between 1990 and 2000 corresponds to 1.2% of 18450ha of the study area. The amendments occurred from 2000 to 2006 are higher than those observed between 1990 and 2000, almost double, standing at 2.1%. There is also to mention the change occurring in Open Woodlands, Shrubs and Herbs towards Permanent Pastures, from 2000 to 2006, since the percentage of this change was greater than the sum of all the changes observed from 1990 to 2000 (Table 3.5. and 3.6.).

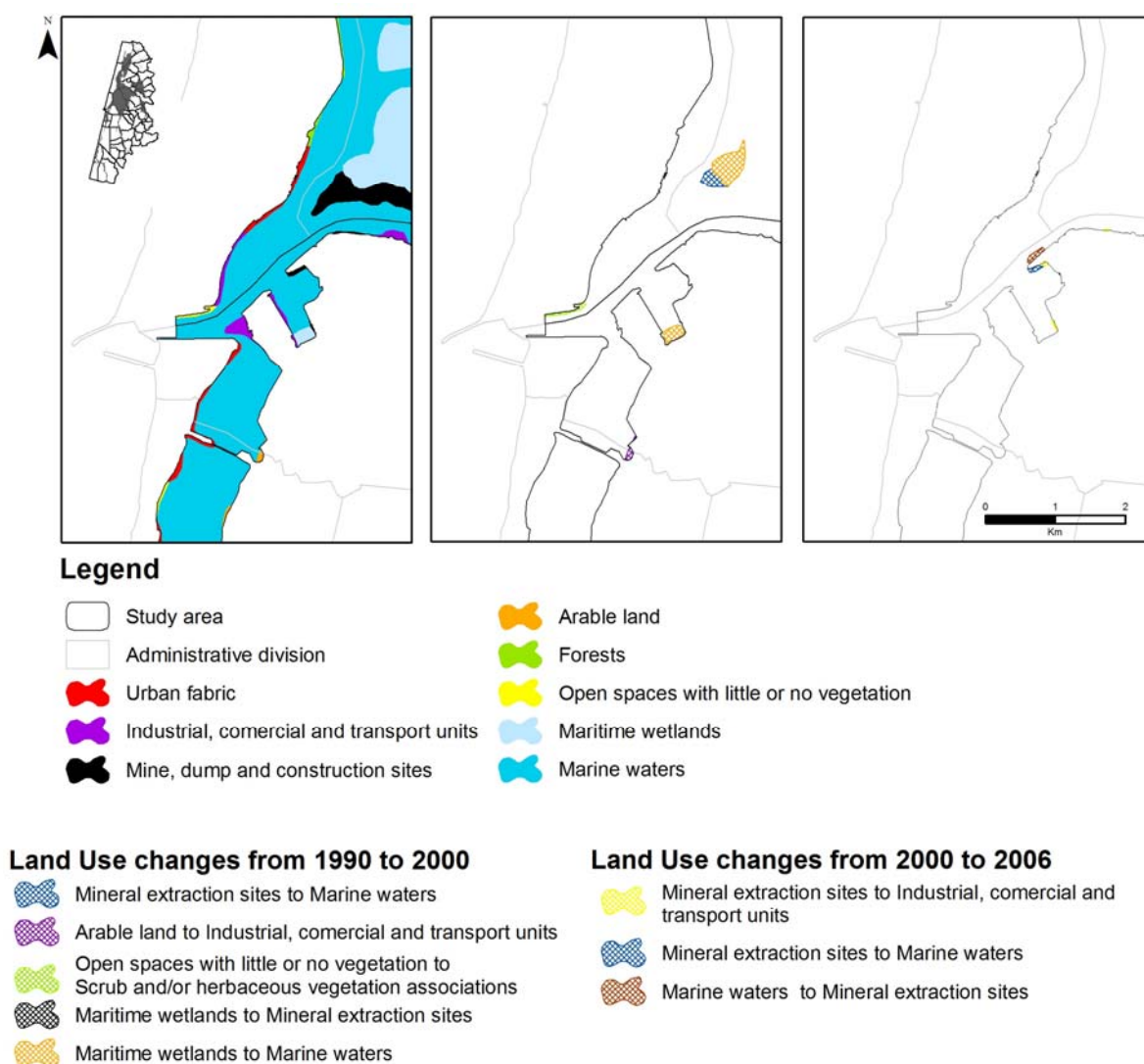


Figure 3.20. Representation of land use in 1990 in the area surrounding the Aveiro Port and changes for the periods from 1990 to 2000 and from 2000 to 2006 (Source: Silva *et al.*, 2011)

Table 3.5. Adjustments in the typologies between 1990 and 2000

Land Use Classes		Area (ha)	% of the total area
MDCS	ICTU	40,7	0,220
	MW	5,5	0,030
AL	ICTU	2,4	0,013
	HAA	12,7	0,069
	MWL	20,3	0,110
HAA	UF	1,5	0,008
	ICTU	2,6	0,014
F	UF	≈0	≈0
	ICTU	1,4	0,007
	MDCS	13,6	0,074
	AL	2,7	0,014
	SHVA	45,5	0,246
SHVA	ICTU	9,3	0,050
OSLNV	SHVA	2,2	0,012
MWL	MDCS	1,7	0,009
	MW	41,8	0,226
MW	ICTU	11,8	0,064
Total		215,7	1,2

Source: Silva *et al.*, 2011

Table 3.6. Adjustments in the typologies between 2000 and 2006

Land Use Classes		Area (ha)	% of the total area
MDCS	SHVA	13,552	0,073
	ICTU	1,080	0,006
	MW	1,047	0,006
HAA	ICTU	4,653	0,025
F	MDCS	0,008	0,000
	SHVA	27,730	0,150
	OSLNV	0,775	0,004
SHVA	UF	0,379	0,002
	P	335,439	1,813
	F	3,498	0,019
MW	ICTU	1,990	0,011
Total		390,152	2,109

Source: Silva *et al.*, 2011

3.3.4. Ecosystems, services and functions

As formerly stated, ecosystems present a set of services which, in turn, present a series of functions. The Ria de Aveiro appears as a wetland and, comparing the surveyed literature, were identified thirteen different types of ecosystems, closely related to the land use patterns previously mentioned, based on the second hierarchic level of the CLC.

Considering, at the same time, the presented characteristics of the Ria de Aveiro, as well as the figures 3.19. and 3.20., the ecosystems identified in the analyzed area provide the following services:

- i) Regulating services (air quality, climate and rainfall, erosion, water treatment and water storage);
- ii) Provisioning services (food; fresh water, timber and fiber);
- iii) Supporting services (soil formation, photosynthesis, nutrient cycle, water cycle);
- iv) Cultural services (diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetics, socials, cultural heritage, recreation and ecotourism).

The specific functions supported by the ecosystems in the study area are described as it follows:

i) Regulation functions:

- Climate regulation - Considered a flood-prone region, the Ria de Aveiro entails a joint between the coast's morphodynamics, the climate changes evolution and sea-level scenarios;
- Water regulation - Regulating runoff and representing a transport means;
- Water supply - Storage of fresh water for drinking, irrigation and industrial use;
- Soil retention - Preventing erosion damage and supplying and preserving the quality of the arable land;
- Soil formation - Providing accumulations of dissolved inorganic nutrients and organic-rich anthropogenic point sources for the productivity maintenance; saturated

soil conditions ensuring a neutral pH that leads to an abundant number of plants and animals;

- Nutrient cycling - High amount of nutrients (nitrogen, phosphorus and silica) due to the freshwater input, though seasonably variable (Lopes *et al.*, 2007); important productivity due to the nutrients and organic materials carried along the salt marshes;

- Biological control - Influenced by the seasonable springs and biological control, presents a good match between the salinity and the water quality variables.

ii) Production functions:

- Food - Supplying an important quantity of fish and edible plants;
- Raw materials - Source of silica sands, salt, timber, fiber, as well as other materials used in local manufacturing processes.

iii) Habitat functions:

- Refuge functions - Living space for species of marine plants and animals;
- Nursery functions - Reproduction habitat for species of marine plants and animals, especially recognized for the oyster nursery parks existing in Costa Nova (salt marshes represent an important nursery area for fish, crustacean and insects).

iv) Information functions:

- Aesthetic information - Specific architecture, city quays and canals, traditional boats, beaches, salt pans and natural reservations;
- Recreation and tourism - Surfing, kite surfing, wind surfing and yachting facilities, fishing, touristic potential in the city of Aveiro and its surroundings (Costa Nova, Barra Beach) as well as other cities in the Ria (Ílhavo, Gafanha de Nazaré, Ovar, Espinho);
- Cultural and artistic inspiration - Creativity source for painters, ceramics and 'azulejo' (Portuguese tin-glazed, ceramic tile work, in shades of blue) and sculpture artists, music concerts and local traditions exhibitions, salt extraction, fishing methods and customs, traditional gastronomy and confectionery;

- Spiritual and historic information - Religious values highlighted by the existing churches and chapels in the region, historical and art museums, local fairs and demonstrations;
- Scientific and educational information - Hosting one of the newest university campuses in Portugal, investing in education, acquiring scientific researches, works of experimental science and involving in the region's cultural and urban development.

3.3.5. Economic value

Several authors such as Costanza (1997), Krieger (2001), Groot (2002), and Raheem (2009) have tried over the years to estimate monetary values for ecosystem goods and services through various methods. However, due to the lack of data, setting values for all the categories defined by the MEA was proved difficult. The first significant results in the estimation of values for ecosystems were developed by Costanza *et al.* (1997) whose classification and values have been widely used ever since. Studies that succeeded in the search of more accurate results have been focusing on prices for different sets of services, which measure the society's willingness to accept the compensation for a loss of the referred service, or the willingness to pay for the continuity or increase of the service provided by the ecosystem in question. Another one of the used techniques is the method known as Contingent Valuation. This method is based on survey (investigations), where people are asked about their willingness to pay for a service provided by an ecosystem, in a scenario, through a description of the service and functions that the ecosystem provides. The result obtained from the surveys is used to estimate the value of ecosystem services.

In the present study were used the values defined by Costanza *et al.* (1997) to calculate the value of ecosystems present in the study area (estuary). The choice of using 1997 values is due mainly to the fact that it presents a more complete set of values, for the study area. The values were not updated since when trying to modify them, it was noted that authors such as Krieger (2001), Martínez *et al.* (2007), Raheem *et al.* (2009) and Brenner *et al.* (2010) continued to use the values calculated by Costanza *et al.* (1997).

It should also be noted that, according to the valuation carried out by Costanza *et al.* (1997), urban ecosystems, UF, ICTU and MDCS are considered to have null economic value.

The table 3.7. shows the correspondence between the descriptions given by Costanza *et al.* (1997) and the ones of the CLC, based on the work of Alves *et al.* (2009), as well as their value in Euros per ha/year. The exchange rate used considers 1 euro corresponding to 1.4053 American Dollars.

The table 3.8. analyses the existing areas for the various ecosystems present in the study area. Considering the values formerly presented (Table 3.5., 3.6. and 3.7.), were obtained the final values for the entire study area in each time period analyzed.

Thus, the results obtained show that in 1990 the study area had a monetary value, for the ecosystems described, of about 132,9 million Euros. In 2000, for the same area, it was estimated a value of around 133,4 million Euros, and in 2006 the area was worth nearly 135,6 million Euros. Finally, considering the proposed scenario, according to which the temporarily flooded areas would proceed to areas permanently covered by water, the Ria de Aveiro and neighboring areas, would be worth about 161,9 million euros.

Table 3.7. Correspondence between types of ecosystems and prices per ha/year

Type of ecosystem according to Costanza <i>et al.</i> (1997)	CLC Type of Ecosystems	Price per ha/year (€)
Urban	Urban Cover	0
Urban	Industry, Commerce and Transport	0
Urban	Areas of Inert Extraction, Hazardous Waste Disposal and Construction Yards	0
Cropland	Temporary Crops	65
Grass/ Rangelands	Permanent Pastures	165
Cropland	Heterogeneous Agricultural Areas	65
Forest temperate/ Boreal	Forestry	215
Grass / Rangelands	Open Woodlands, Shrubs and Herbs	165
Floodplains/ Swamps	Bare Areas and with Little Vegetation	13933
Floodplains / Swamps	Inland Wetlands	13933
Tidal marsh / Mangroves	Littoral Wetlands	7109
Lakes / Rivers	Inland Waters	6047
Estuaries	Marine and Coastal Waters	16247

Calculated by Costanza *et al.*, 1997

In light of the results, and an initial analysis, it can be stated that direct application of the values of Costanza *et al.* (1997), during the analysis period of the study area, has increased, regarding its economic value (ecosystems), though at a slow pace. From 1990 to 2000 there was a growing economic value of only 0,4%, while from 2000 to 2006 a growth of 1.6% was observed. In the case of the theorized hypothesis, the growth was estimated at about 16,2%.

Table 3.8. Areas per ecosystems

Ecosystems	Area (ha) 1990	Area (ha) 2000	Area (ha) 2006	Area (ha) Scenery
UF	127,2	128,7	188,2	0
ICTU	62,2	130,3	129,2	0
MDCS	93,6	62,8	5,1	0
AL	2590,3	2557,5	2740,9	0
P	706,6	706,6	1100,8	0
HAA	903,0	911,6	668,2	0
F	670,2	606,5	657,2	0
SHVA	1323,2	1362,1	696,9	0
OSLNV	32,2	30,0	69,7	6378,5
IWL	172,6	172,6	172,9	0
MWL	6750,9	6709,3	6910,6	0
IW	29,3	29,3	67,7	12079,1
MW	4996,3	5050,3	5050,1	0

Source: Silva *et al.*, 2011

The value of the study area in 2006 was of 135,6 million Euros, while the investment of the POLIS Litoral Ria de Aveiro was around 96 million Euros. However, in the work of Martinez *et al.* (2007) it is stated that the value of the entire Portuguese coast is of 695,03 million Dollars.

As for the present study, the value for only a limited area is higher 100 million Euros, it is clearly relevant that an analysis on a higher scale could lead to a series of valuation errors.

Chapter IV

Conclusions and Final Remarks

Coastal and estuarine areas all over the world are regarded as a target of pressure resulting from the development of societies. The exchanges between ecosystem services have increased the production of certain goods for the markets in the detriment of the loss of some services. One of the contemporary challenges focuses on the economic quantification of these changes in order to improve the management of coastal and estuarine areas. Given that the values of ecosystems and their services are not constant in time, it matters to establish an approach that considers an estimation of monetary values of the similar ones.

Considering the human activities' intervention on the sustainability of ecosystems, attempts are made in the present, in order to conserve the delivery of goods and services, through costly alternatives.

The process introduced by the present study is the economic valuation of ecosystems, especially of those that are not traded in the market place. Society's willingness to accept the compensation for a loss of the referred service was measured, as well as the willingness to pay for the continuity or increase of the service provided by the ecosystem in question. The aim of the analysis was to highlight the importance of the economic activities related to wetlands, as well as to stress the importance of wetlands and their conservation, for people.

Authors' efforts to agree on a common idea of ecosystem services couldn't avoid the release of several highlighted differences. Terminologies differ in terms of key

components and processes necessary to deliver an ecosystem service, as well as human interventions in their delivery.

The ecological and social systems are complex, dynamic and interlinked, and human intervention does not always include the consequences of its actions in management processes, on the short and long term. It is necessary to account for uncertainties and changes in the market trends for a better establishment of a properly order of distribution of costs and benefits. Cultural, spiritual and aesthetic values are of great importance for setting up effective relations between equity and fairness. Institutions with expertise in coastal zone management should also adopt an open attitude towards the inclusion of new types of information in their decision-making processes.

The growing knowledge in the scientific area in question may become essential for the improvement of the preservation of vital ecosystems and the decision-making, regarding spatial planning.

The Portuguese coastal areas are very important. Beside the fact that they are located in the main centers of political decision-making, commercial and industrial centers, tourism infrastructures and other employment opportunities, these areas are highly populated and have an important contribution to the country's economic development.

The Aveiro Lagoon brings a high contribution to the local economy and to the environment. Acting as a keystone to the local agricultural and bearing an important number of small traditional fishing ports, it also stands out due to its aquaculture activities and its significant potential for tourism, water sports and traditional salt production activities.

Situated on the northern coast of Portugal, the Ria de Aveiro is a shallow water lagoon, supplied with water by the Antuã and Vouga rivers and separated from the Atlantic Ocean by an artificial sand dune barrier, opened in the beginning of the 19th century. The importance of the area lays in the fact that it includes a series of Natura 2000 sites that require the interest of the Portuguese state in adopting modern management solutions.

The need for an integrated management, in the area of coastal zones, plan emerged from the lack of coordination between the governmental institutions and management stakeholders. ICZM strategies showed their particular help in the management of the lagoon, allowing the elaboration of action plans, strategies and intervention proposals. Starting with the MARIA research project which established the communication path for the following one, ESGIRA MARiA, the coordination between stakeholders was improved and later, by the UNIR@RIA plan, the population also participated in the lagoon's management. Highly superior to the first two, the POLIS LITORAL Ria de Aveiro introduced a pre-established budget for each project, concluding to a fast financing and execution. After ten years of attempts, there was a significant improvement in the implementation of ICZM principles and a more effective deployment.

Distinguishing itself as an important wetland, Ria de Aveiro, through the existing ecosystems, yields an important percentage of the services and functions agreed upon by the Millennium Ecosystem Assessment (2005). Regulating, provisioning, supporting and cultural services are provided across the study area and supported by the connected functions.

Raging from regulation functions that imply climate, soil, water and biological regulation, as well as nutrient cycling, the area supplies production functions: food and raw materials for the local and neighborhood population and economy, and stands for habitat for an important number of animals and plants. Related to the information functions, the Ria de Aveiro is a representative area in terms of cultural heritage, historical, religious and artistic values.

Considering the economic value of the study area for 2006 and taking into account that the values are presented in terms of provided services per ha/year, it appears that the 135,6 million Euros constitute a significantly higher value than the investment seen in perspective, in the recovery and conservation of the Ria de Aveiro. The POLIS Litoral Ria de Aveiro (PARQUEXPO, 2008) presents a budget for the entire area of the Ria de Aveiro of about 96 million Euros.

Taking into account the available amounts, mostly limited, for actions of protection and enhancement, it is necessary to classify and prioritize the actions to be taken. The studies of economic valuation of ecosystems must be a part of the decision-making processes, in order to optimize the existing economic resources while conserving and enhancing the ecosystems of greatest value.

Martínez *et al.* (2007) works out a global analysis of the value of coastal areas. The value he calculated for the Portuguese coast is of 695.03 million Dollars. In this study, with a more detailed analysis, the figures for a significantly reduced area are above a hundred million Euros. This fact highlights the need for detailed and comprehensive analyses, since the analysis on a larger scale can lead to errors in valuation.

Another important figure to stress is related to the values identified by Costanza *et al.* (1997). These figures are merely representative and it would be required to explore, correct and update them in order to achieve a real economic value of the services and goods provided by the ecosystems in the study area.

It is therefore considered that the application of such a study to an area of the Portuguese territory must be supported by surveys (investigations) that reflect the reality at local, regional and national levels. There were also identified some errors in the cartography used, thus making it compulsory to perform an update of the land uses and functions (e.g. mapping habitat grids with less than 25 ha). It is certainly necessary to realize a significant unbundling in land use categories and ecosystems in order to draw the conclusions obtained in this study closer to the reality of the Ria de Aveiro and other similar sites.

Appendixes

APPENDIX 1

Distribution of EU coastal regions and share of coastal population within 50 km of the sea

EU countries with a sea border	Coastal regions (NUTS III) with a sea border	Coastal regions (NUTS III) without sea border and more than half of its population within 50 km of the sea	Total number of coastal regions (NUTS III)	Share of total coastal regions with more than 50% of its population within 50 km of the sea	Share of total coastal regions with more than 75% of its population within 50 km of the sea	Share of the coastal regions inhabitants residing within 50 km of the sea
BE	5	9	14	100%	93%	97%
BG	3	0	3	100%	100%	85%
DK	11	0	11	100%	100%	100%
DE	29	14*	43	98%	86%	73%
EE	4	0	4	100%	75%	95%
IE	7	0	7	86%	86%	88%
EL	40	4	44	100%	91%	98%
ES	31	0	31	97%	94%	94%
FR	30	0	30	80%	67%	72%
IT	60	7	67	99%	90%	95%
CY	1	0	1	100%	100%	100%
LV	3	0	3	100%	100%	95%
LT	1	0	1	100%	100%	98%
MT	2	0	2	100%	100%	100%
NL	15	9	24	100%	96%	97%
PL	7	2	9	78%	44%	74%
PT	13	4	17	100%	100%	97%
RO	2	0	2	100%	50%	72%
SI	1	2	3	100%	100%	95%
FI	10	1	11	91%	73%	89%
SE	14	0	14	100%	64%	86%
UK	83	22	105	100%	95%	97%
EU22	372	74	446	97%	88%	91%

*Hamburg has been included in this column

Adapted from the Eurostat Gisco database.

APPENDIX 2

POLIS LITORAL Ria de Aveiro - The 4 intervention axes

AXIS 1: Protection and regeneration of the lagoon and coastal zone, aiming risk prevention

- includes projects aimed at consolidating the dunes barrier and strengthening the lagoon margins, recovery of dams and waterfronts, thus ensuring the preservation of lagoon and dunes system, minimizing the risk of exposure of people and goods and regeneration of the degraded areas, fundamental for biophysical balance of Aveiro.

AXIS 2: Protection and enhancement of natural and landscape heritage

- includes interventions of regeneration and enhancement of the natural areas in the Natura network, by improving the basic conditions that allow to connect the conservation of the natural heritage to the environment of the Ria.

AXIS 3: Enhancement of resources as a factor of social and economic competitiveness

- includes a set of projects that allow the enhancement and boost of the resources of the Ria, ensuring a leading position of the Ria de Aveiro in the context of the region in which it belongs.

AXIS 4: Upgrade and revitalization of the Ria environment

- includes projects and activities of dredging the canals and marking in order to promote mobility and navigability of the Ria de Aveiro, the enhancement of lagoon sides and information campaigns and spatial promotion according to a strategy that simultaneously allows: to organize and ensure the existence of effective and qualified answers for the different needs of those who work, live and visit the Ria de Aveiro.



APPENDIX 3

**INVESTMENT OF THE PLAN OF INTERVENTION
OF THE POLIS LITORAL RIA DE AVEIRO**

PLAN OF INTERVENTION: ACTIONS		Total Investment (VAT included)
Axis 1	Protection and regeneration of the lagoon and coastal zone, aiming risk prevention	€34.912.000
RA1	Dunes & lagoon regeneration	€17.640.000
RA1.1	Protection and regeneration of the dunes system	€9.840.000
RA1.2	Transposal of sediment for the optimization of the hydrodynamic equilibrium	€7.800.000
RA2	Redevelopment and regeneration of the coastline in Esmoriz and Cortegaça	€552.000
RA3	Strengthening the banks for the recovery of dams and waterfronts for risk prevention	€16.720.000
Axis 2	Protection and enhancement of natural and landscape heritage	€15.834.030
RA4	Study of the coastal and estuarine evolution and dynamic	€750.000
RA5	Characterization study of the ecological quality of the Ria	€250.000
RA6	Construction of buildings in the public hydric domain along the banks of the Ria	€250.000
RA7	Conservation and regeneration of the natural values	€14.584.030
RA7.1	Regeneration and enhancement of the 'pateiras' of Fermentelos and Frossos	€8.328.830
RA7.2	Regeneration and enhancement of the Mira barrier and lagoon and the Mar lake	€1.255.200
RA7.3	Regeneration and enhancement of the Esmoriz barrier site	€3.600.000
RA7.4	Regeneration and enhancement of the Vouga River site	€530.000
RA7.5	Regeneration of the areas of public fruition of the São Jacinto Dunes Natural Reserve.	€870.000
Axis 3	Enhancement of resources as a factor of social and economic competitiveness	€13.521.549
RA8	Study of economic activities and their dynamics	€250.000
RA9	Redevelopment and enhancement of the fishing activity	€10.000.984
RA9.1	Maritime fishing cores	€1.823.211
RA9.2	Lagoon fishing cores	€8.177.773
RA10	Establishment of structures for the support of bathing tourism (regeneration of beaches)	€3.270.566

Axis 4	Upgrade and revitalization of the Ria environment	€21.403.957
RA11	Upgrade of the mobility and planning of the circulation along the Ria	€5.317.300
RA11.1	Study of mobility and shipping in the lagoon	€250.000
RA11.2	Land marking and signposting of the navigation canals	€312.000
RA11.3	Upbringing road cycling as a way of living of the Ria	€4.755.300
RA12	Redevelopment and regeneration of the lagoon sides	€7.665.600
RA12.1	Lagoon sides of Ovar	€1.329.600
RA12.2	Lagoon sides of Murtosa	€540.000
RA12.3	Lagoon sides of Estarreja	€1.857.000
RA12.4	Lagoon sides of Aveiro	€660.000
RA12.5	Lagoon sides of Ílhavo	€1.500.000
RA12.6	Lagoon sides of Vagos	€1.080.000
RA12.7	River sides of Mira	€699.000
RA13	Information and spatial advertising	€4.876.145
RA13.1	Spatial marketing plan	€500.000
RA13.2	Portas da Ria/Routes, information equipment and publicity for the existing values	€4.376.145
RA14	Upbringing and upgrading facilities for nautical recreation	€3.544.912
	Structure and intervention management costs	€10.343.641
	Intervention base studies (Strategic Plan and Environmental Assessment)	€300.000
	Structure costs	€1.028.058
	Intervention management costs	€6.126.874
	Other financial costs	€2.888.709
	TOTAL INVESTMENT	€96.015.178

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